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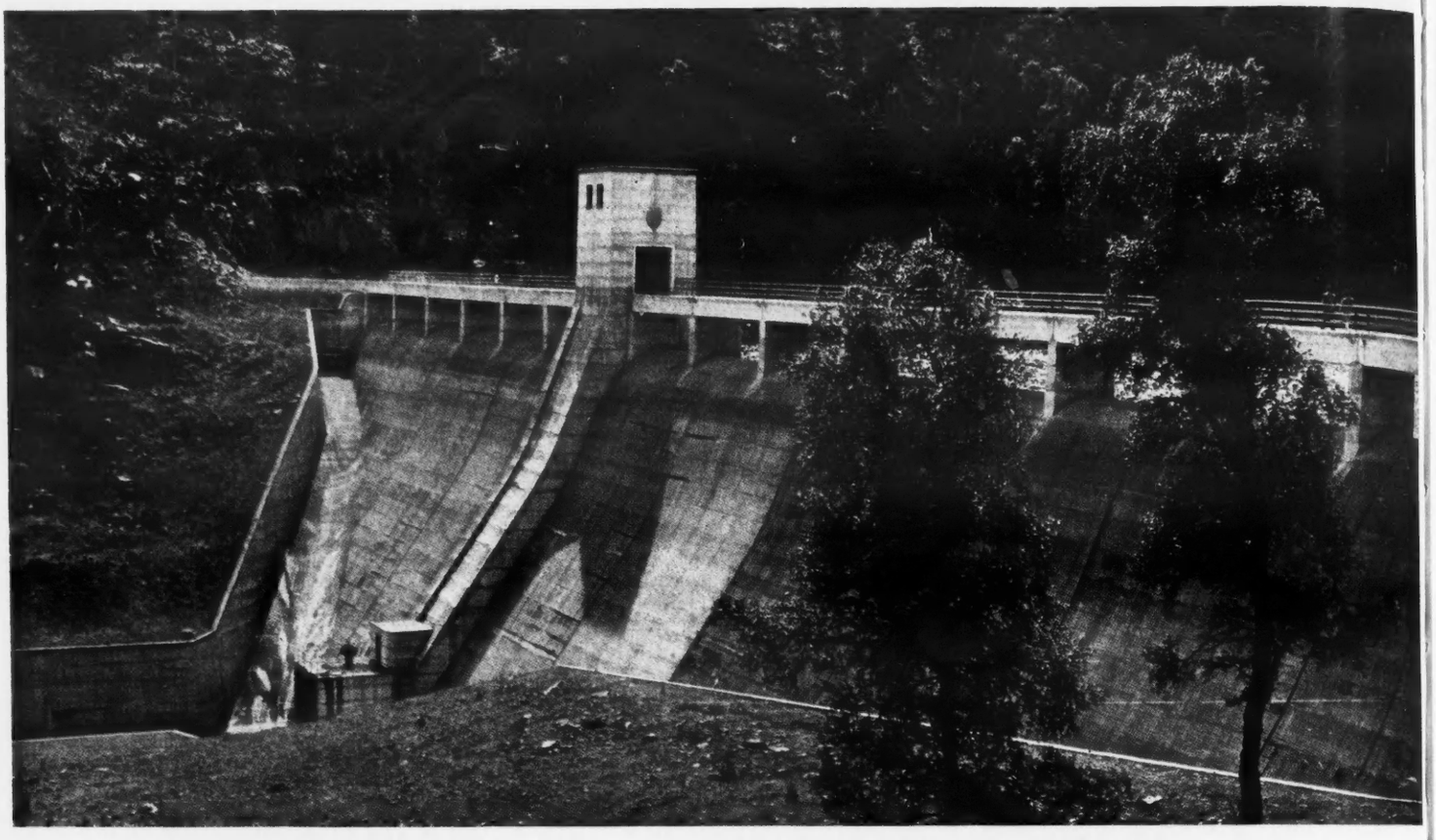

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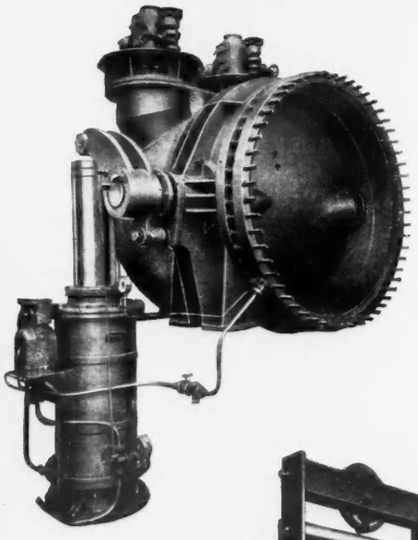

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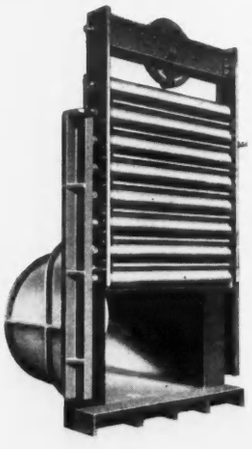

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Established 1856

No. 5451 **JULY 15, 1960** VOL. 210

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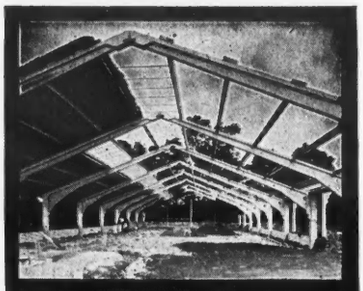

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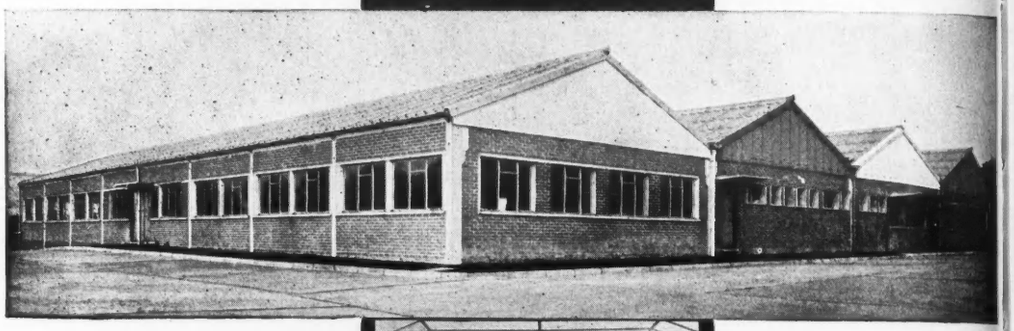

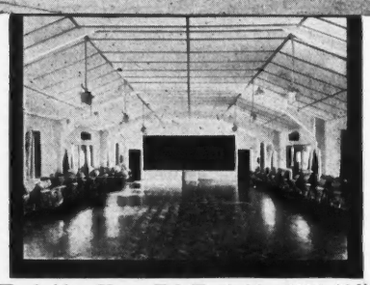

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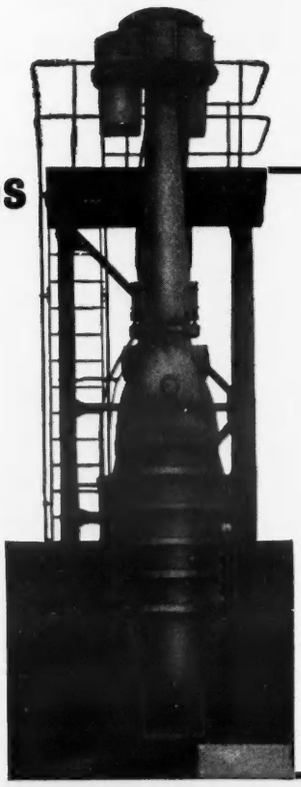

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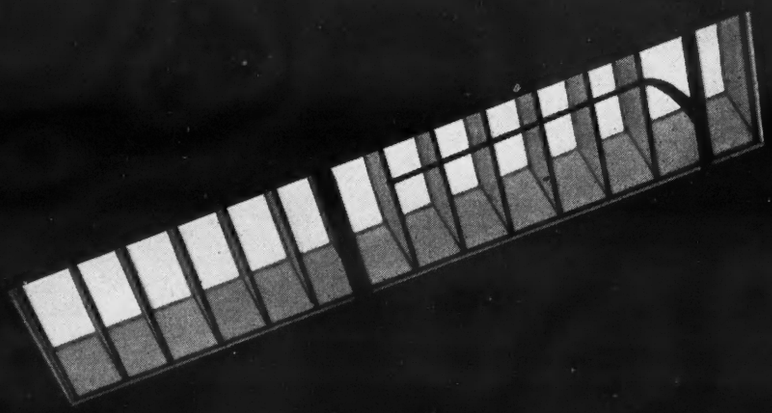

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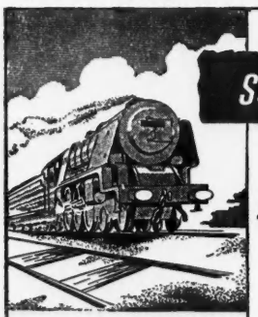

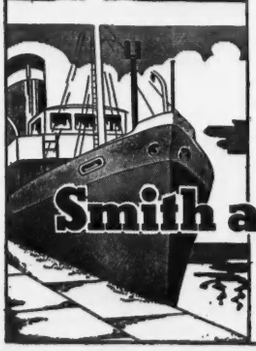

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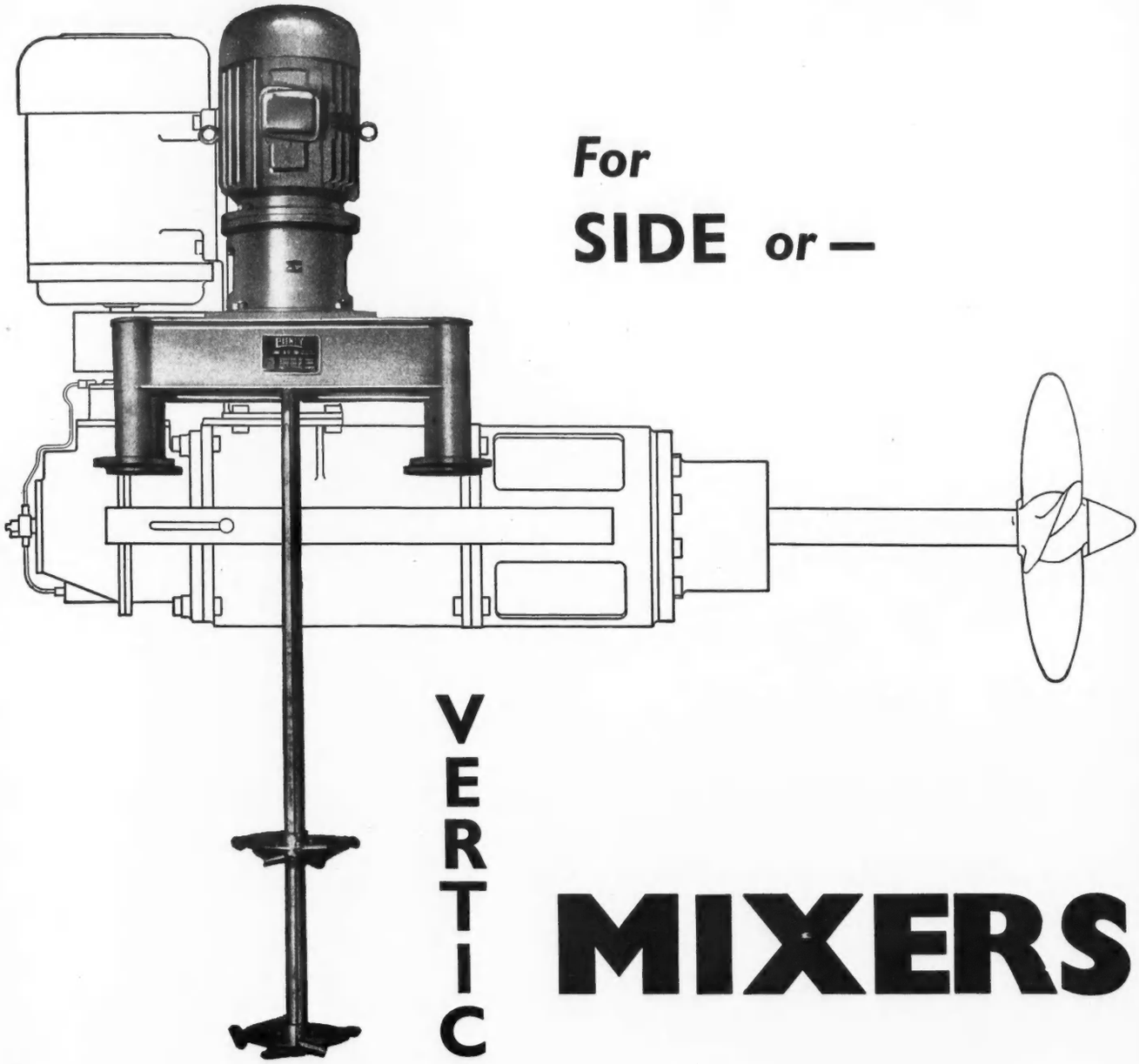

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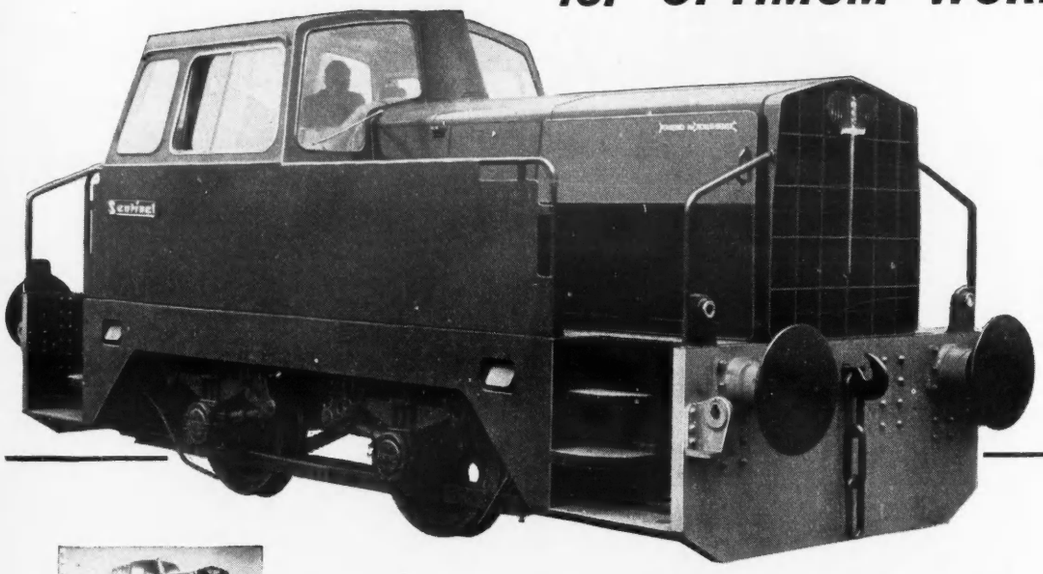

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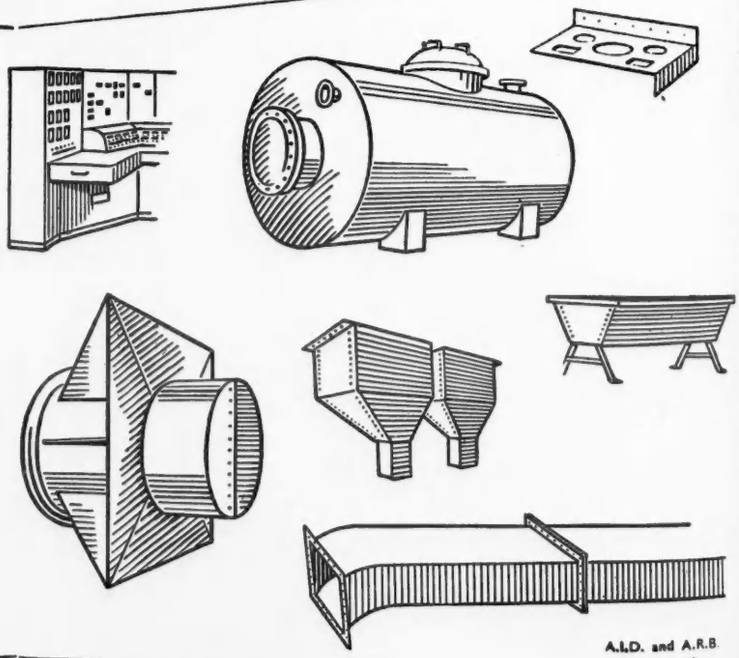

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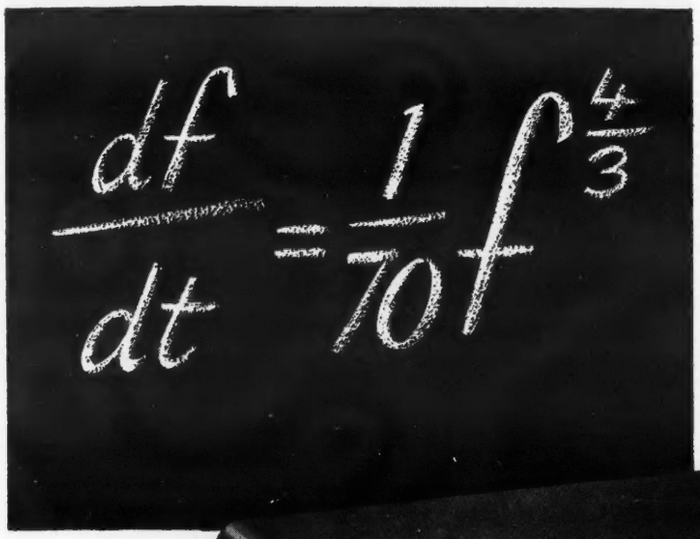

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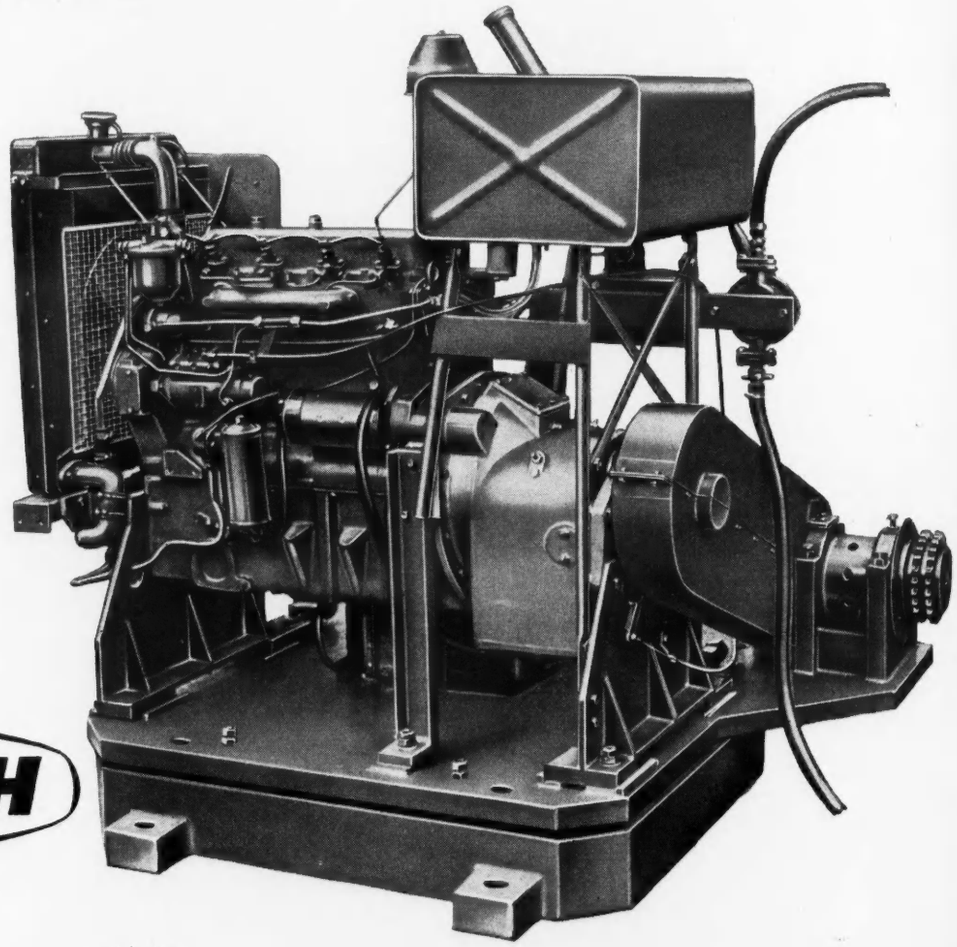

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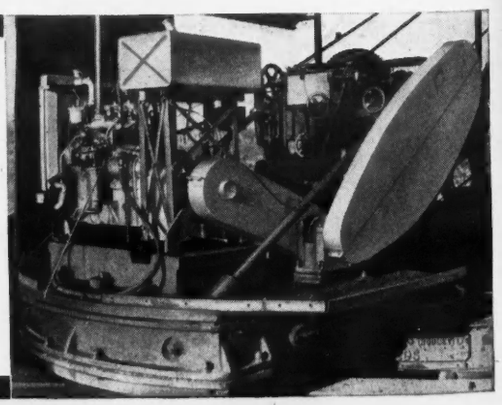

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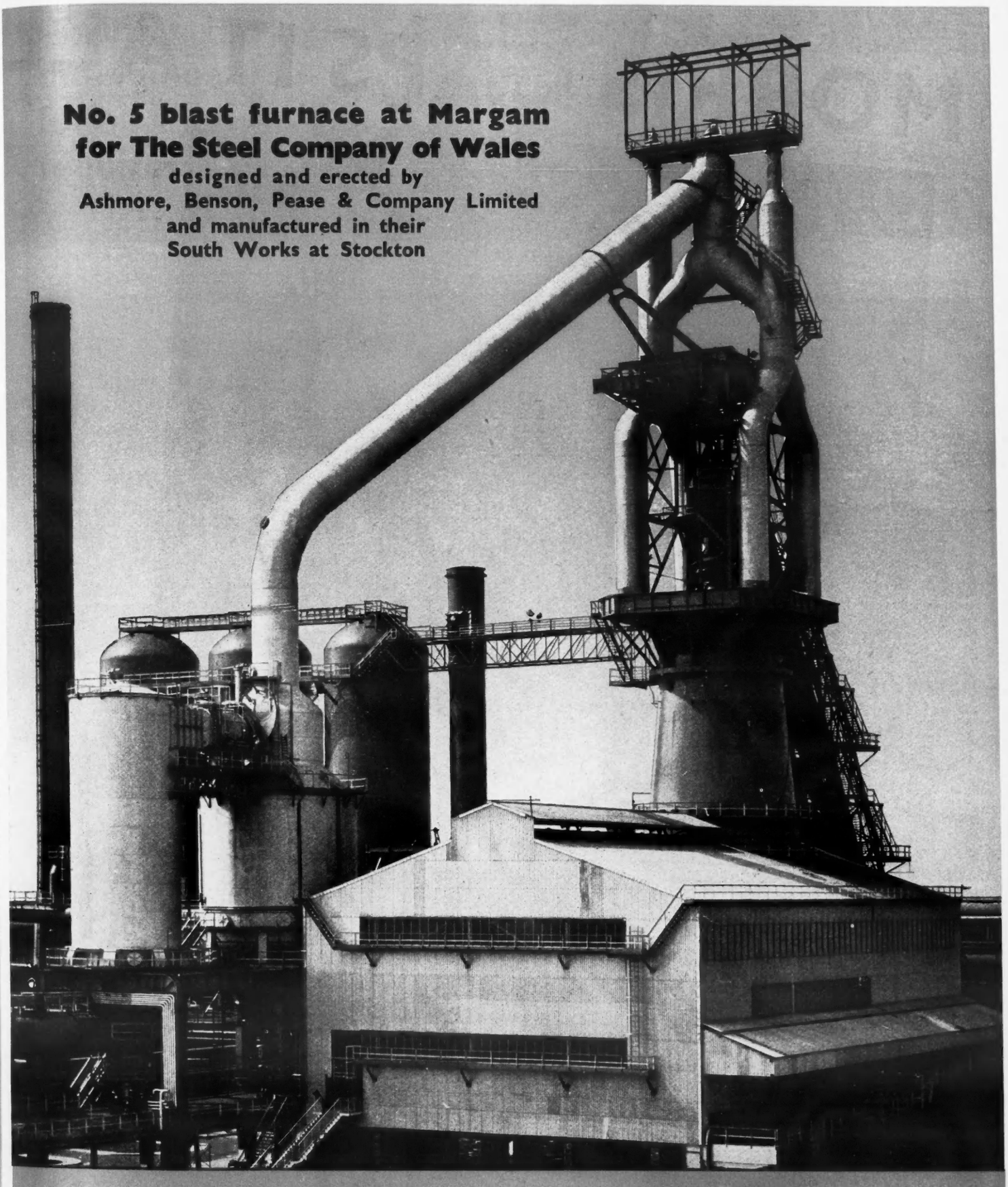

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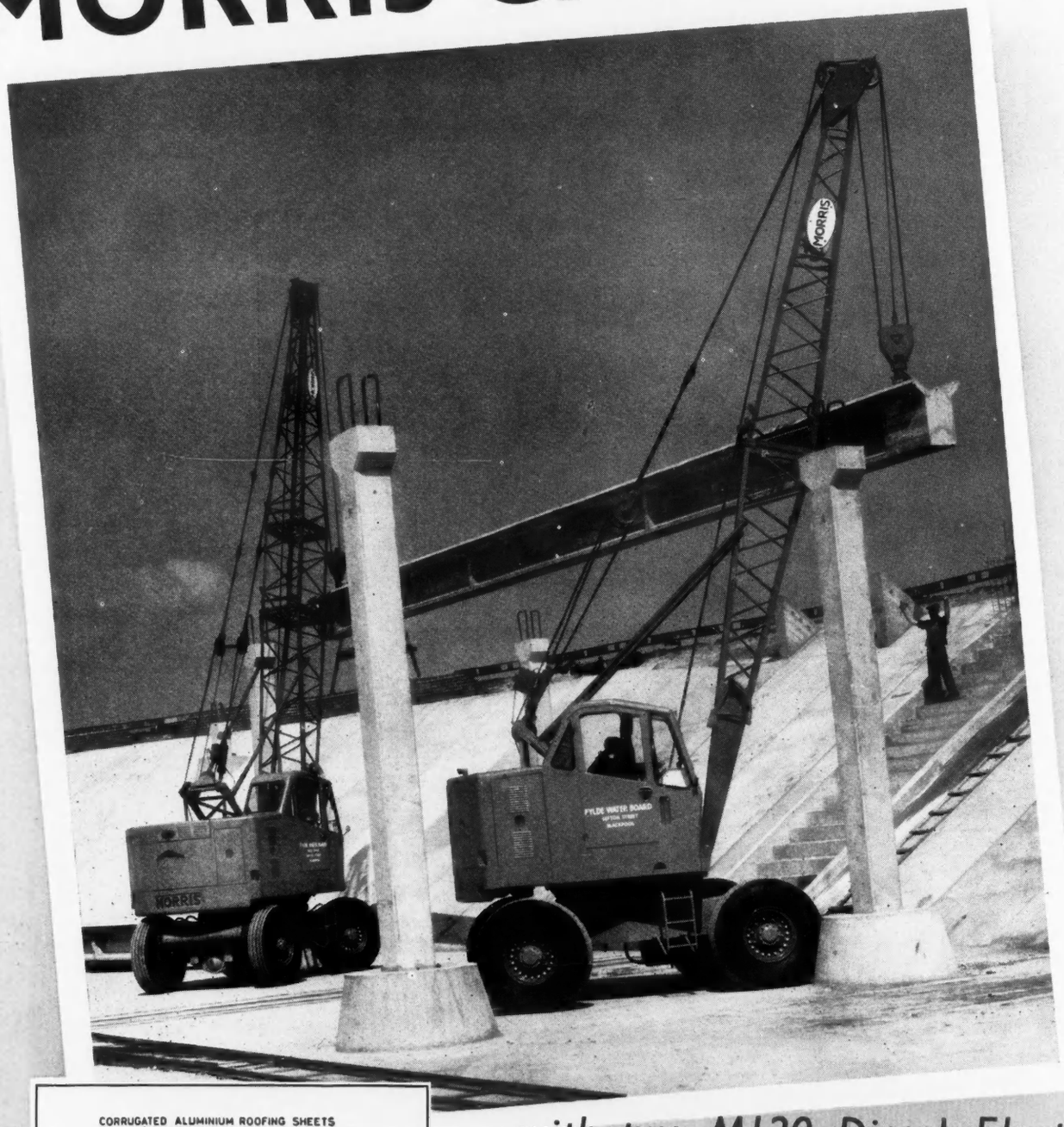

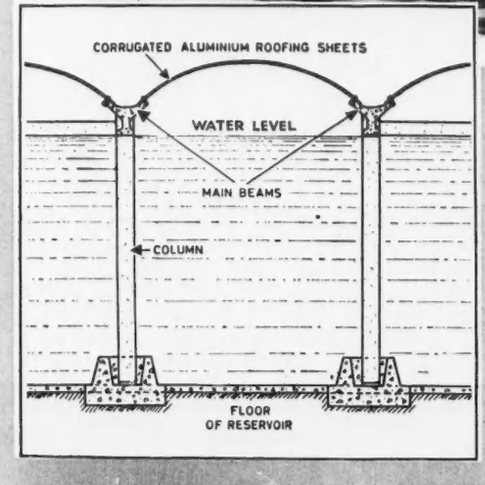

with two M120 Diesel Electric
MOBILE CRANES

The Morris 6 ton mobile cranes illustrated, are erecting the columns and the main beams which will support the aluminium sheet roof of a 16 million gallon concrete lined reservoir now being constructed at Weeton, Lancs., for the Fylde Water Board. Each crane has a 35ft. jib made up of two 15ft. sections and one 5ft. centre section.

The cranes lend themselves admirably to a somewhat unusual situation involving partial dismantling, so that they can be passed through an 8ft. wide culvert leading to the floor of the reservoir basin where they are seen operating.

Although, in this instance, the cranes are shown fitted with strut jibs, the Morris range of mobiles embraces cranes with cantilever jibs, truck and lorry mounted types up to 6 tons capacity in addition to similar alternative range for loads up to 3 tons.

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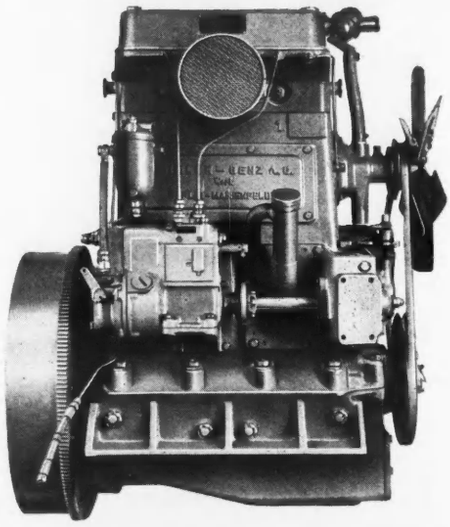

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M 203 B	W	3/S	54 – 90	750 – 1200	5 1/2	8 1/4	591.9	2150
M 204 B	W	4/S	72 – 120	750 – 1200	5 1/2	8 1/4	789.0	2715
OM 636	W	4/S	17 – 35	1500 – 3000	2 15/16	3 15/16	107.8	495
OM 312	W	6/S	47 – 77	1500 – 2400	3 9/16	4 3/4	279.5	784
OM 321	W	6/S	55 – 94	1500 – 2600	3 3/4	4 3/4	311.2	784
OM 315	W	6/S	80 – 124	1200 – 1800	4 7/16	5 1/2	505.0	1700
OM 326	W	6/S	97 – 155	1200 – 1800	5 3/64	5 1/2	660.0	1720
MB 851	W	1/S	9 – 20	1000 – 2000	4 1/2	5 1/2	88.8	662
MB 861	L	1/S	9 – 20	1000 – 2000	4 1/2	5 1/2	88.8	662
MB 852	W	2/S	18 – 40	1000 – 2000	4 1/2	5 1/2	176.9	915
MB 862	L	2/S	18 – 40	1000 – 2000	4 1/2	5 1/2	176.9	915
MB 853	W	3/S	27 – 60	1000 – 2000	4 1/2	5 1/2	266	1122
MB 863	L	3/S	27 – 60	1000 – 2000	4 1/2	5 1/2	266	1122
MB 854	W	4/V	36 – 80	1000 – 2000	4 1/2	5 1/2	354.4	1245
MB 864	L	4/V	36 – 80	1000 – 2000	4 1/2	5 1/2	354.4	1245
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MB 846 B	W	6/Li	114 – 250	750 – 1500	5 7/8	7 1/2	1230.2	3970
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MB 846 Ad ▼	W	6/S	148 – 320	750 – 1500	5 7/8	7 1/2	1230.2	4200
MB 846 Bb ▽	W	6/Li	148 – 320	750 – 1500	5 7/8	7 1/2	1230.2	4200
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MB 836 Db ▼	W	6/S	370 – 650	1000 – 1500	6 7/8	8 1/16	1806.3	5050
MB 820 B	W	12/V	460 – 750	1000 – 1500	6 7/8	8 1/16	3612.6	6180
MB 820 Bb ▽	W	12/V	640 – 1100	1000 – 1500	6 7/8	8 1/16	3612.6	6900
MB 820 Db ▼	W	12/V	770 – 1350	1000 – 1500	6 7/8	8 1/16	3612.6	7240
MB 837 A	W	8/V	165 – 440	1000 – 2000	6 1/2	6 7/8	1825	2940
MB 837 Aa ▽ ▽	W	8/V	215 – 550	1000 – 2000	6 1/2	6 7/8	1825	3020
MB 835 Ab ▽	W	12/V	840 – 1450	1000 – 1500	7 1/2	9 1/2	4773	8157
MB 835 Bb ▼	W	12/V	1015 – 1780	1000 – 1500	7 1/2	9 1/2	4773	8597
MB 839 Ab ▽	W	16/V	1120 – 2000	1000 – 1500	7 1/2	9 1/16	6380	11020
MB 839 Bb ▼	W	16/V	1350 – 2400	1000 – 1500	7 1/2	9 1/16	6380	11450
MB 518 B ▼ ▼	W	20/V	3000	1720	7 5/16	9 13/16	8201.5	10550

Note:

W = water cooling · L = air cooling
Li = horizontal · S = vertical
V = vee type · ▽ = with exhaust-turbo-supercharging · ▼ = with exhaust-turbo-supercharging and boost intercooling · ▽ ▽ = with mechanical supercharging
▼ ▼ = with mechanical supercharging and boost intercooling

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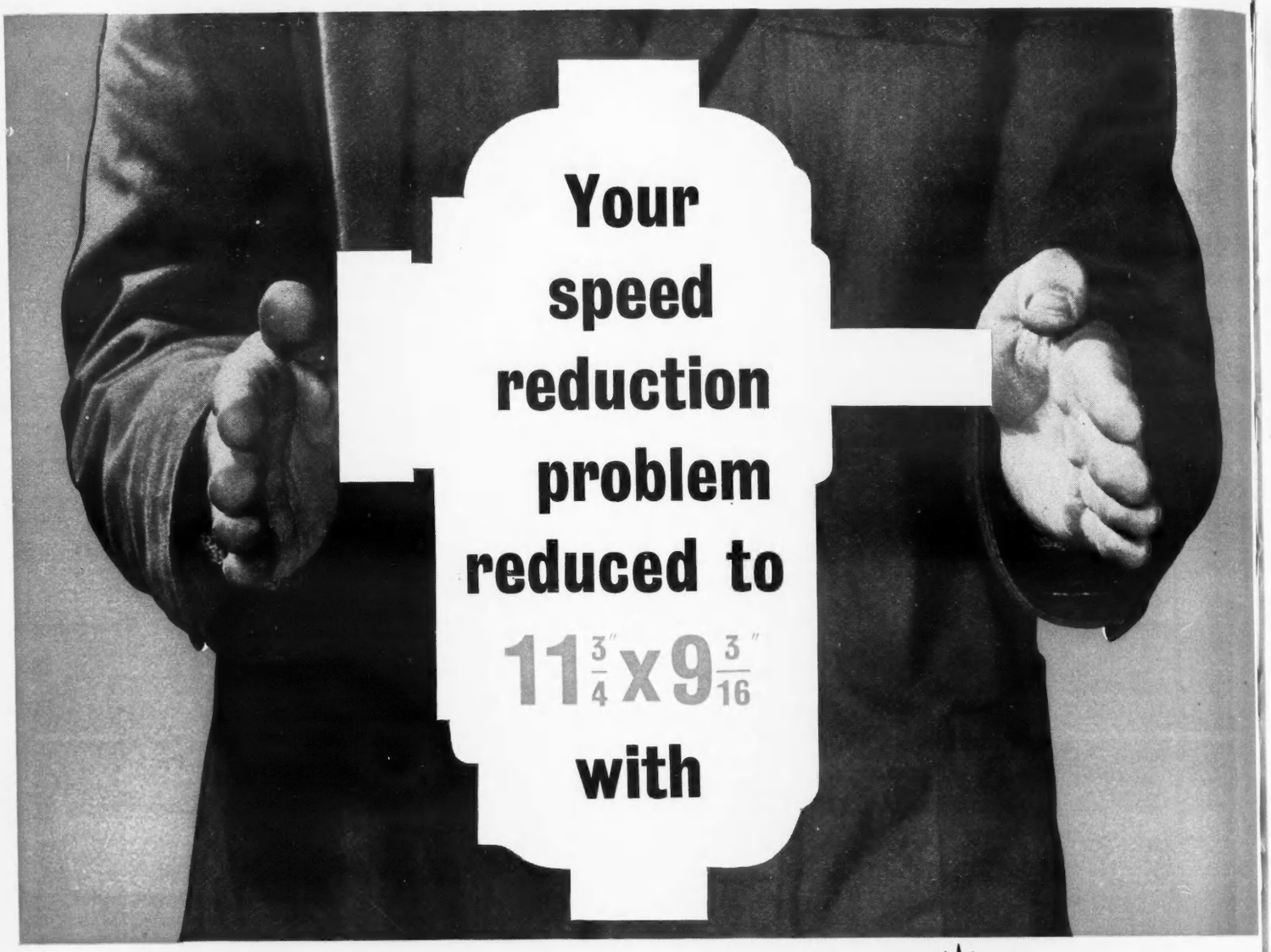

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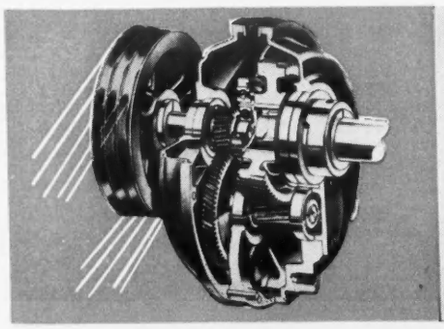

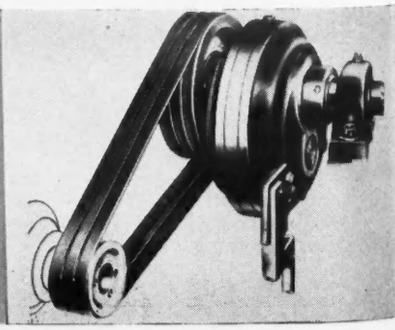

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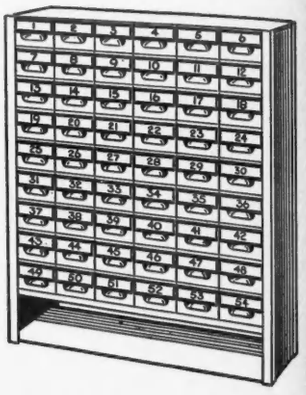

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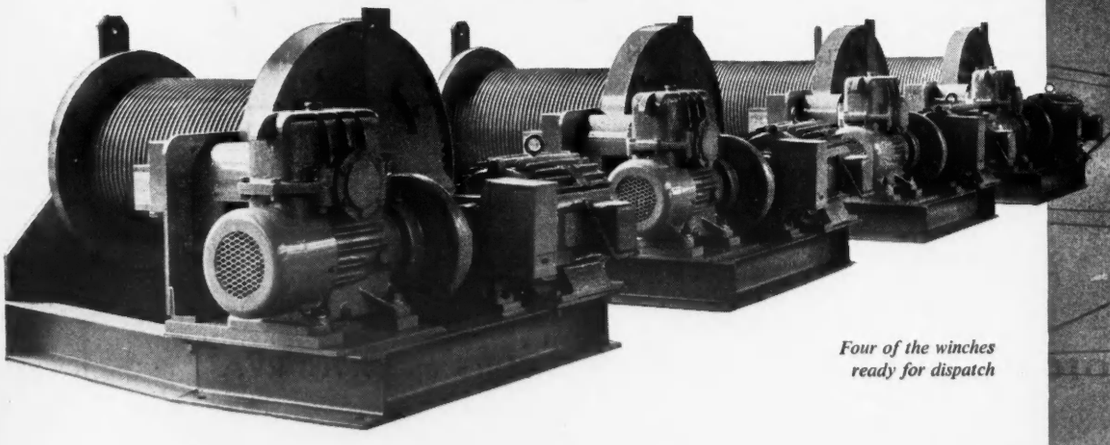
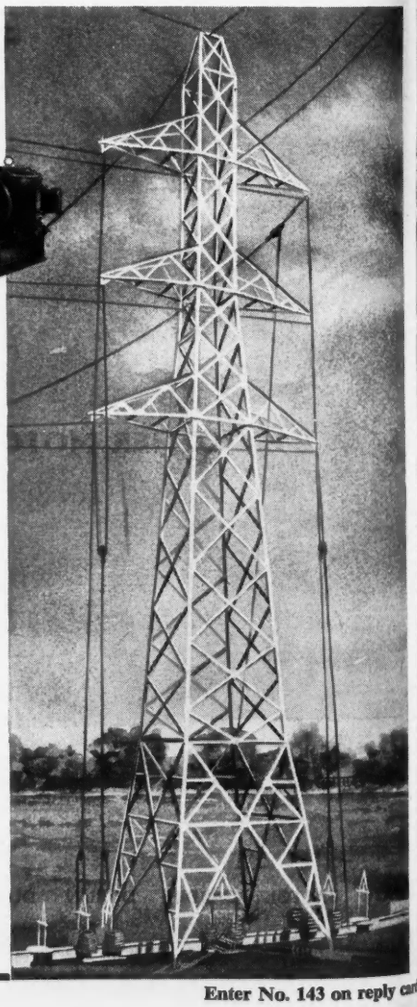


Four of the winches ready for dispatch



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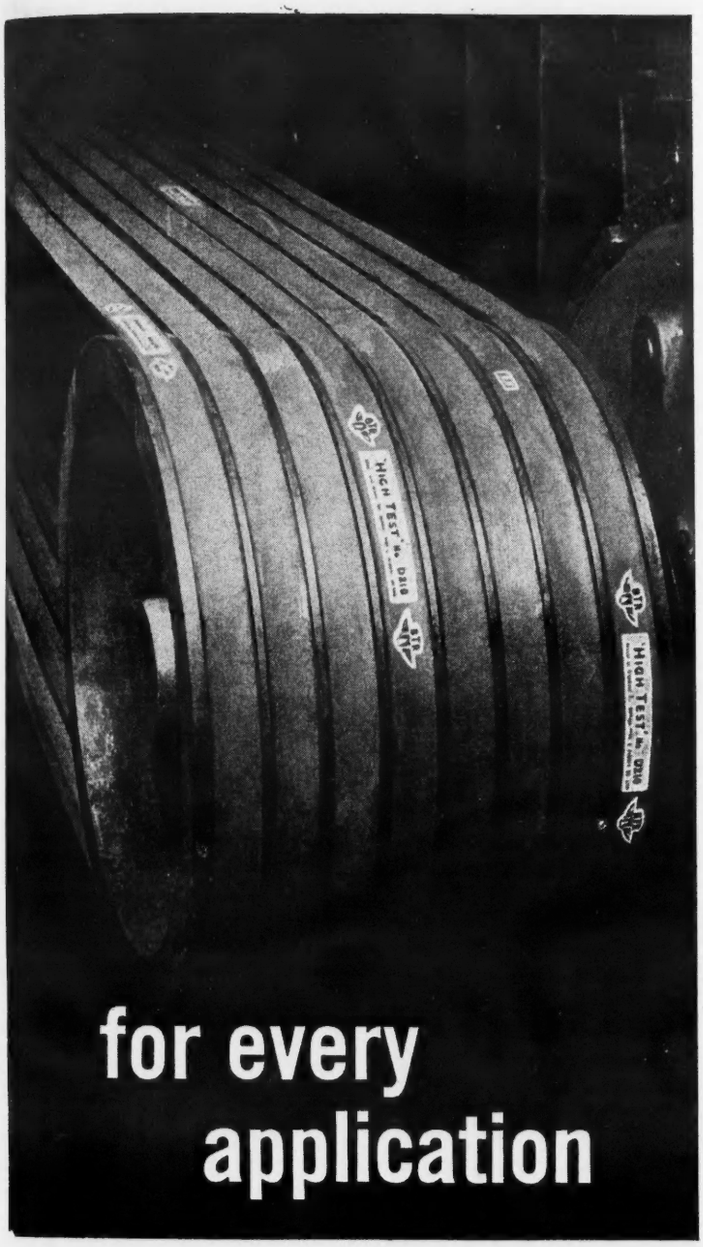

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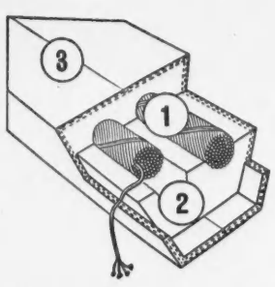

This diagram shows (1) the load-carrying members (2), the rubber cushion and (3) the 2 ply cover of specially woven wear resisting material of a BTR High Test V-Belt. This Grommet construction is available in Sections B, C, D and E.

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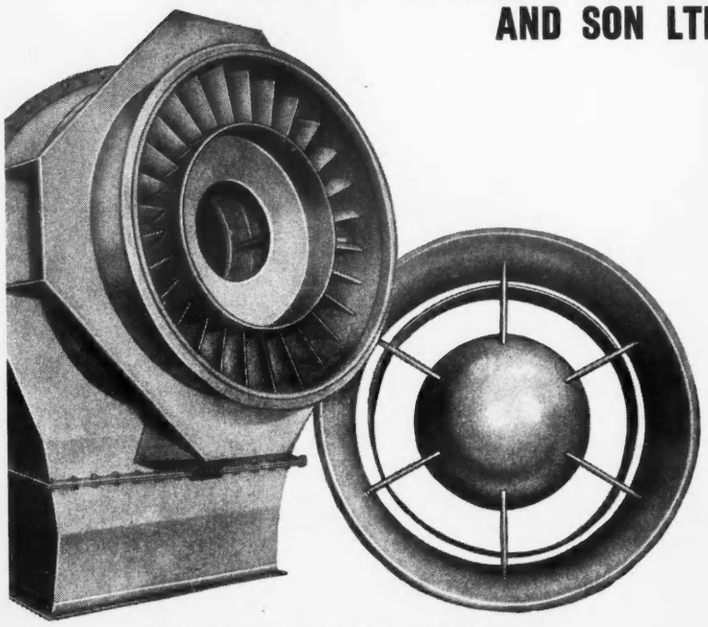

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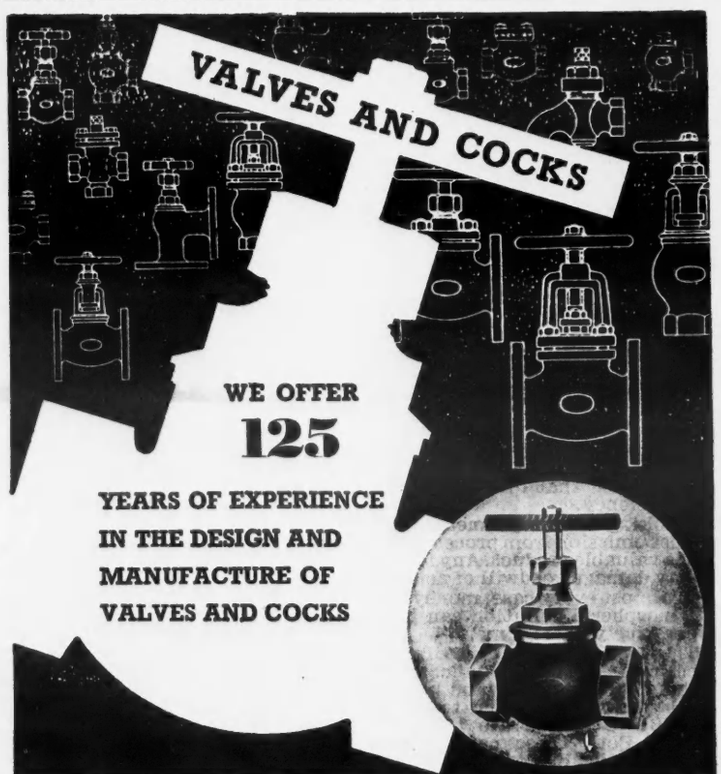

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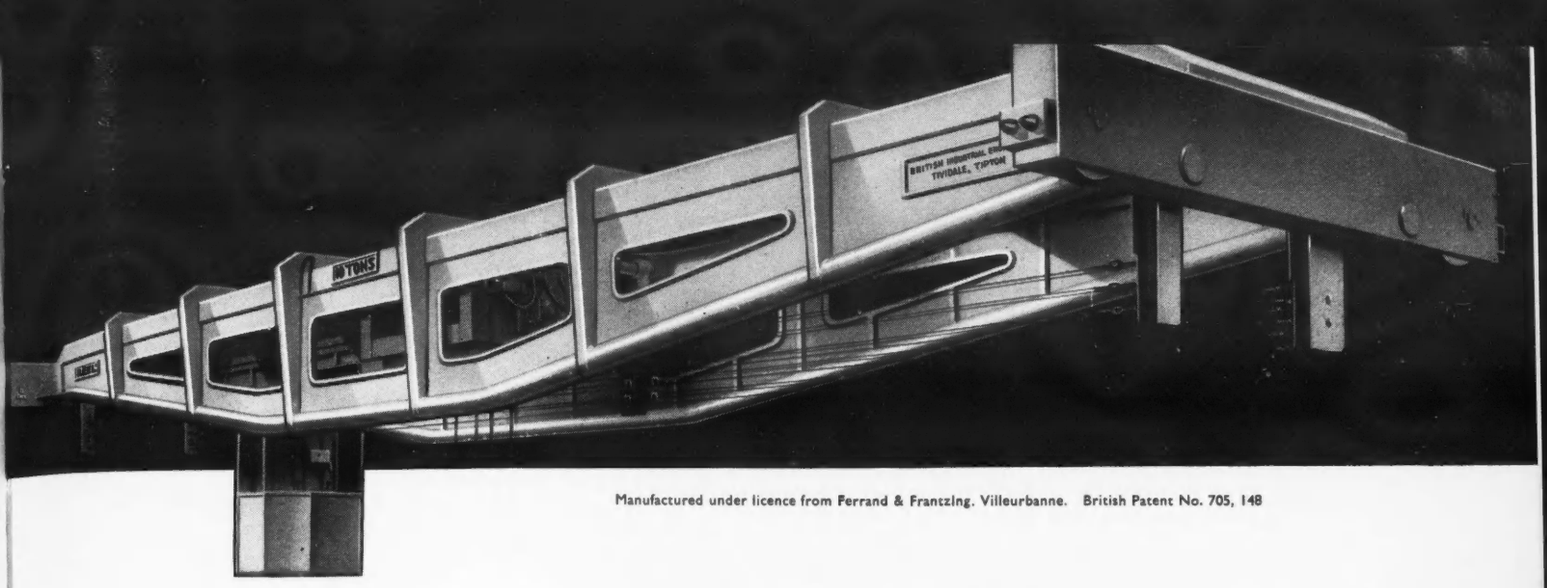

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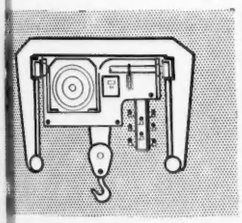

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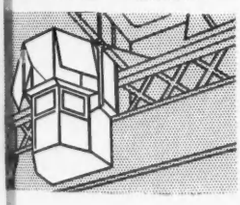

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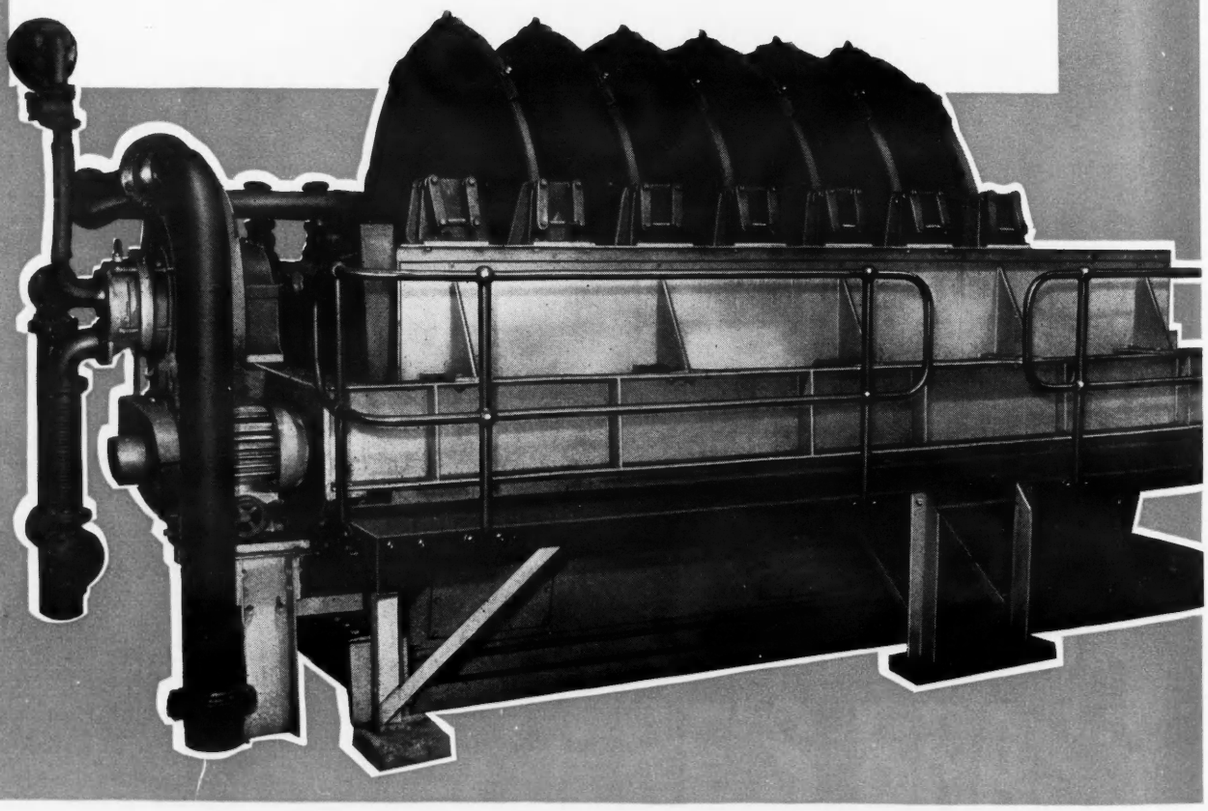

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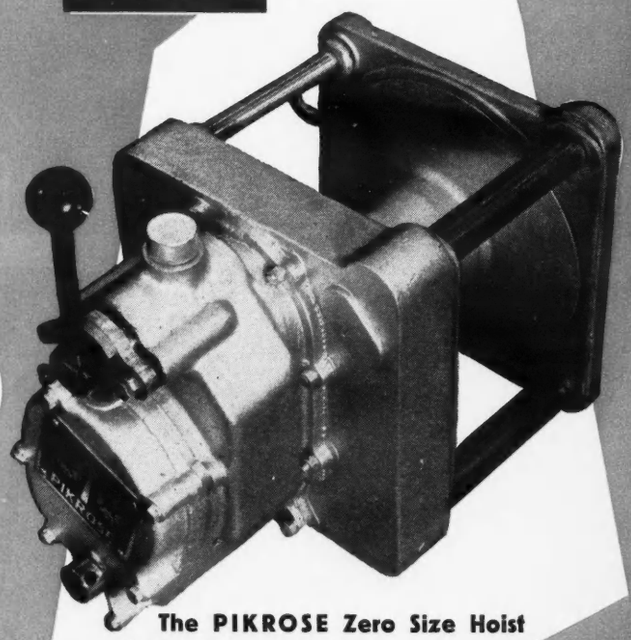

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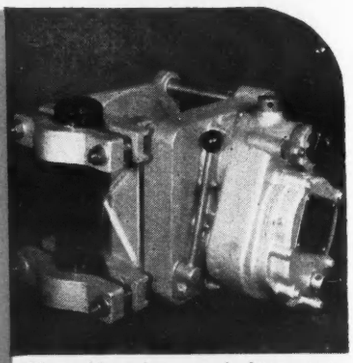
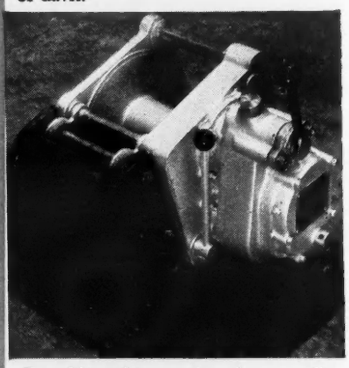
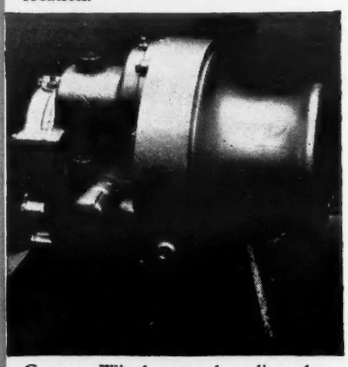


Clamp Mounting—attached to a post or davit.



Base Mounting—anchored to a cradle which may be fixed at any convenient location.



Capstan Winch—can be adjusted to either a vertical or horizontal position as required.

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Motor of 3 H.P.
Capacity of drum 330 ft. ¼" rope.

Capstan Winch Model
Rope pull 800 lbs. at 90 f.p.m.
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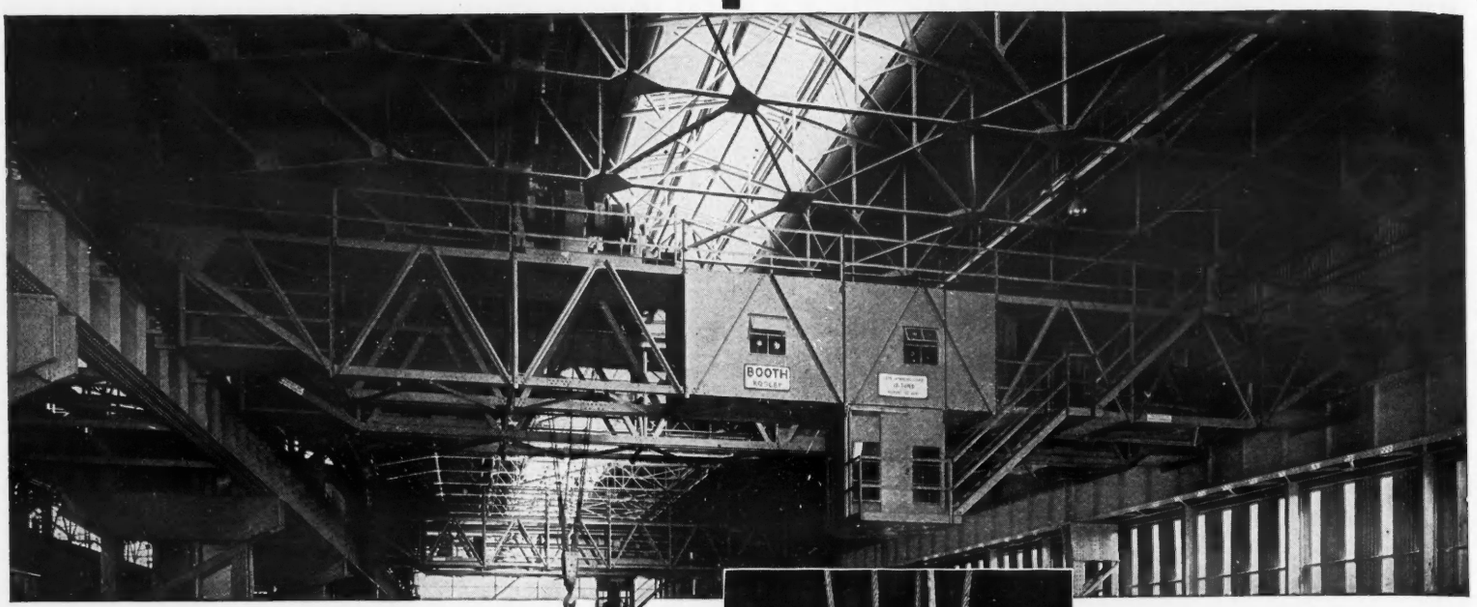
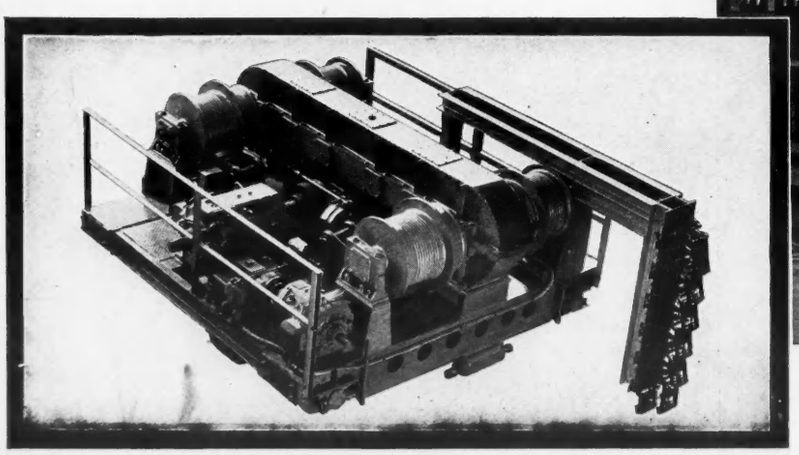


(ABOVE) Clyde-Booth four point suspension electric overhead travelling magnet crane at Messrs. Colvilles Ltd., Ravenscraig Works.
(RIGHT) The hook with slip-ring gear for the magnet, showing attachment of the four ropes.
(BELOW) The special four barrel crab.



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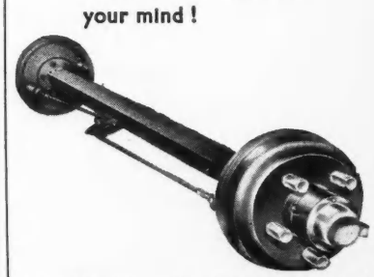

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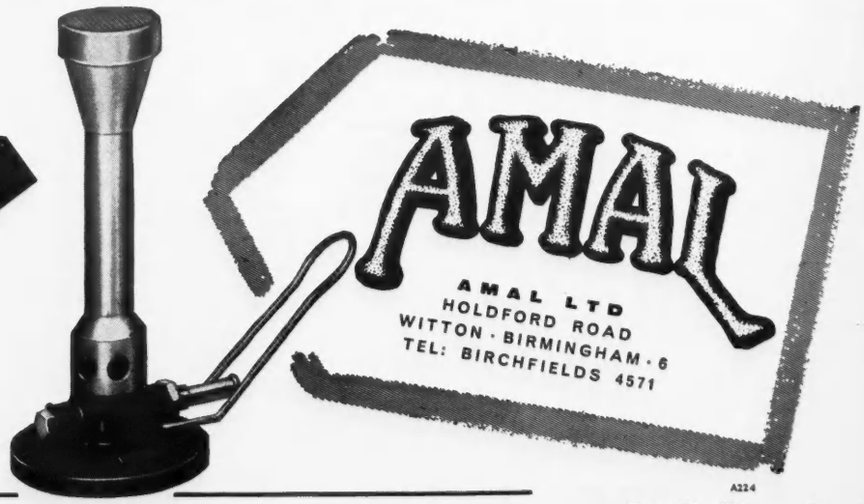

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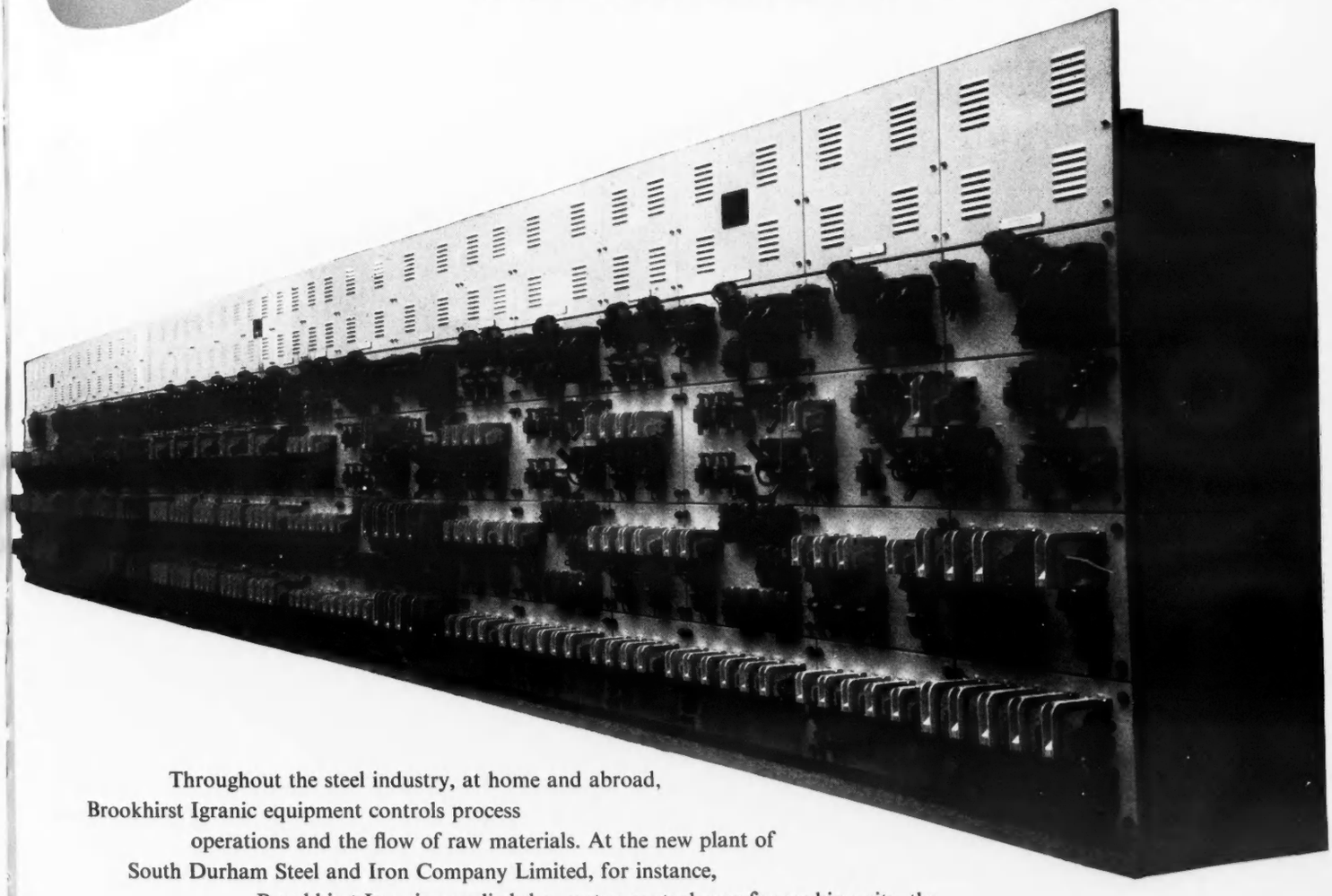

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There can be no finer tribute than this to the quality and reliability built in to Brookhirst Igranic control.

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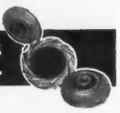

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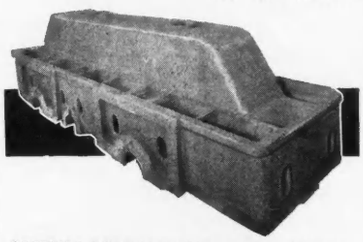

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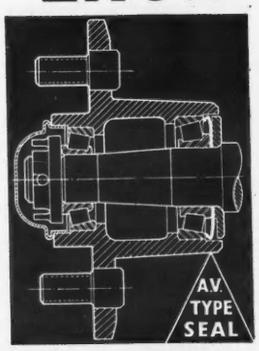

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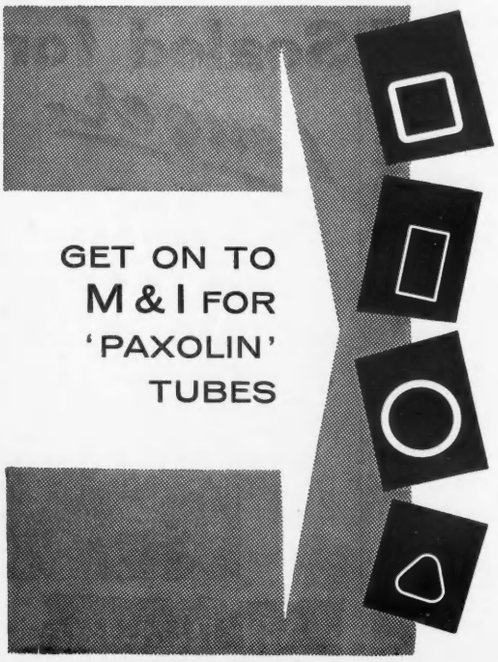

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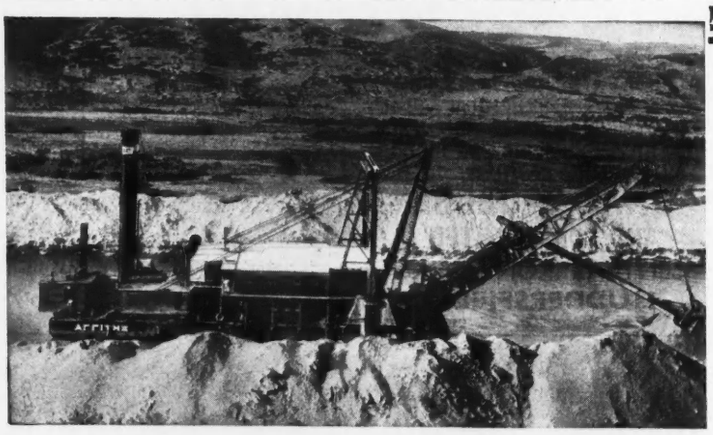

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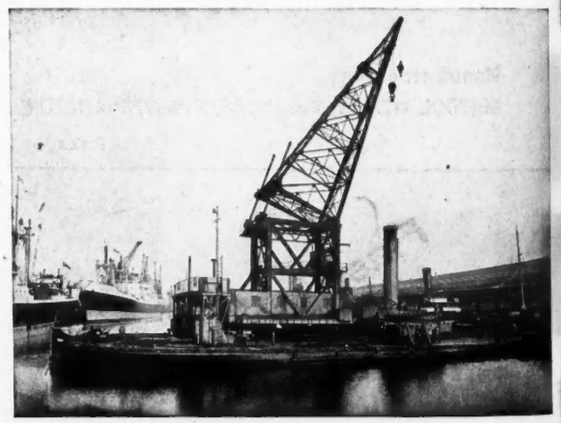

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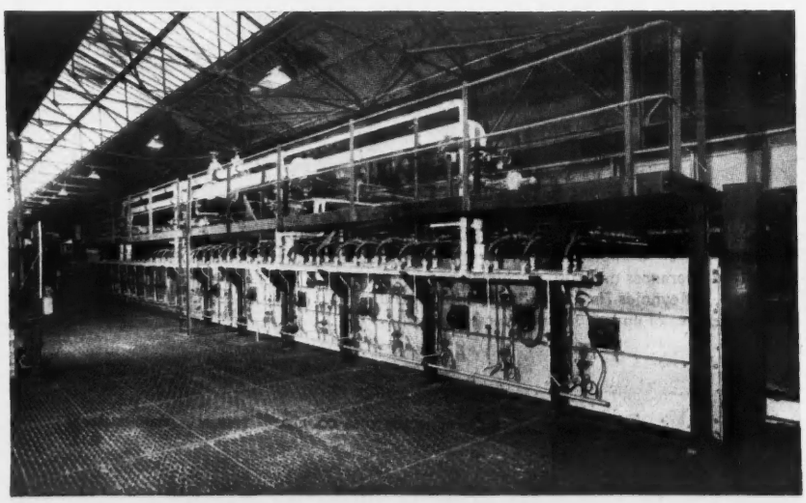

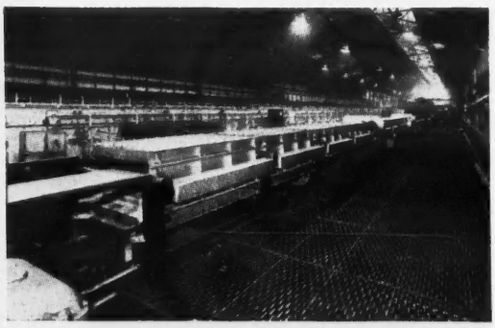

GB

View of — Water Cooling Section

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G103

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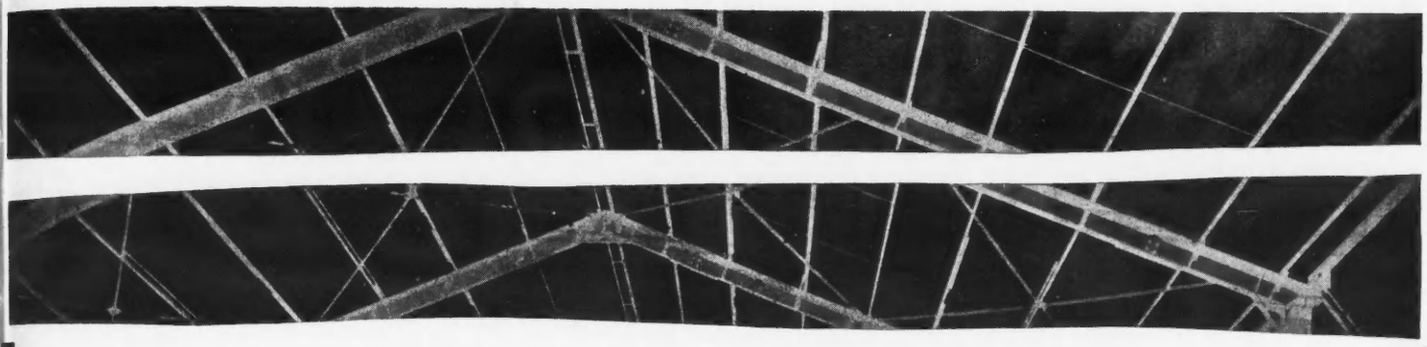
The Portal Roof...



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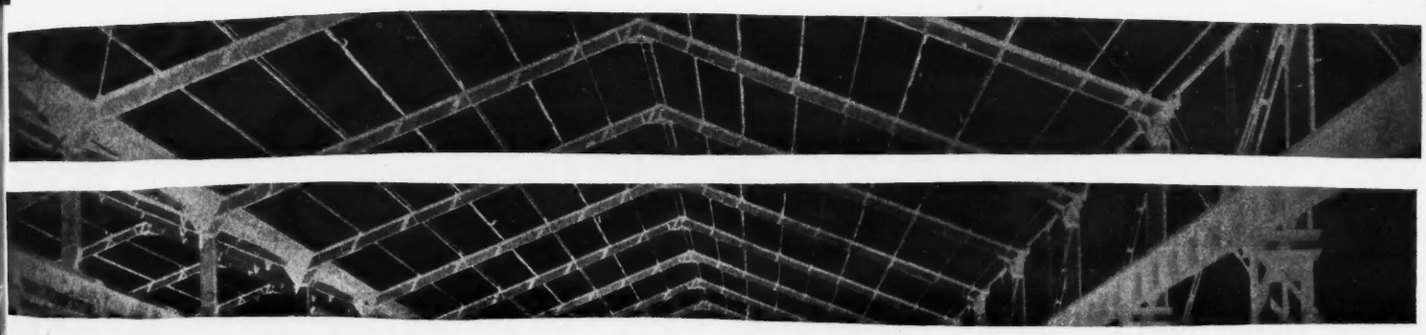

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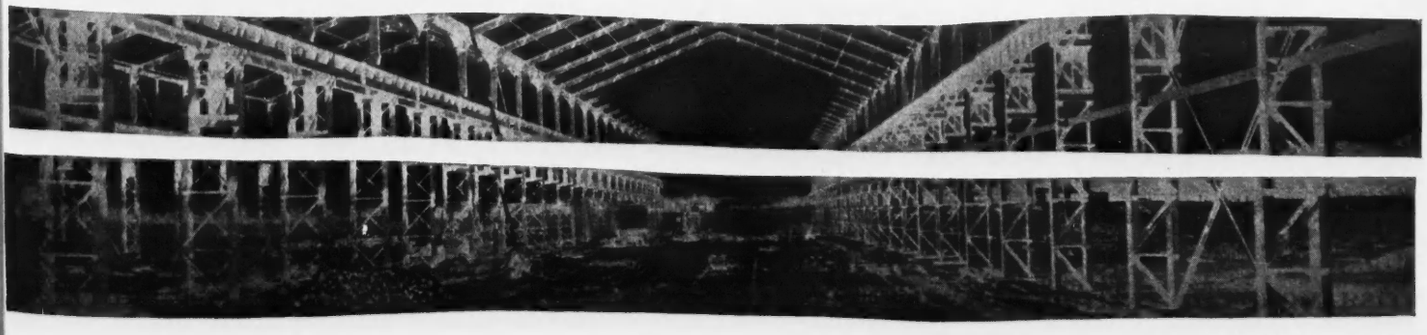

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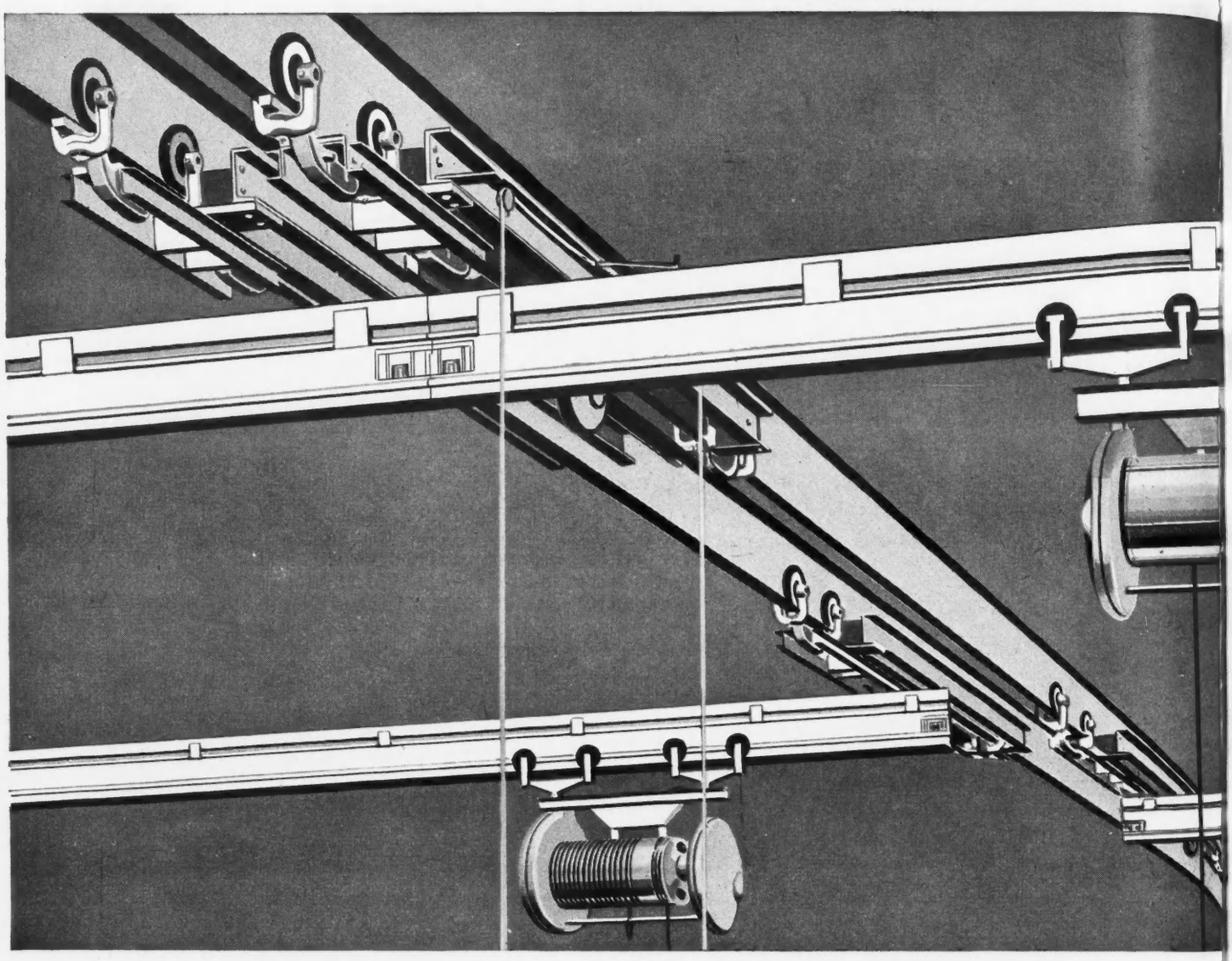

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Underslung interlocking bridge cranes in the MonoRail System give extreme flexibility of movement overhead. One lifting hook can cover an entire factory floor, and loads of up to 5 tons can be moved and set down to order. The special 'latch bolt' design of the cranes ensures the safe, efficient and simple transit of trolley wheels across connecting interlocks. Further, bridges can be interlocked at every point with spur tracks of MonoRail for transferring loads beyond the factory area into store, or to and from despatch bays.

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Milling spindle can be slightly inclined in 4 directions to avoid drag on the cutting tools

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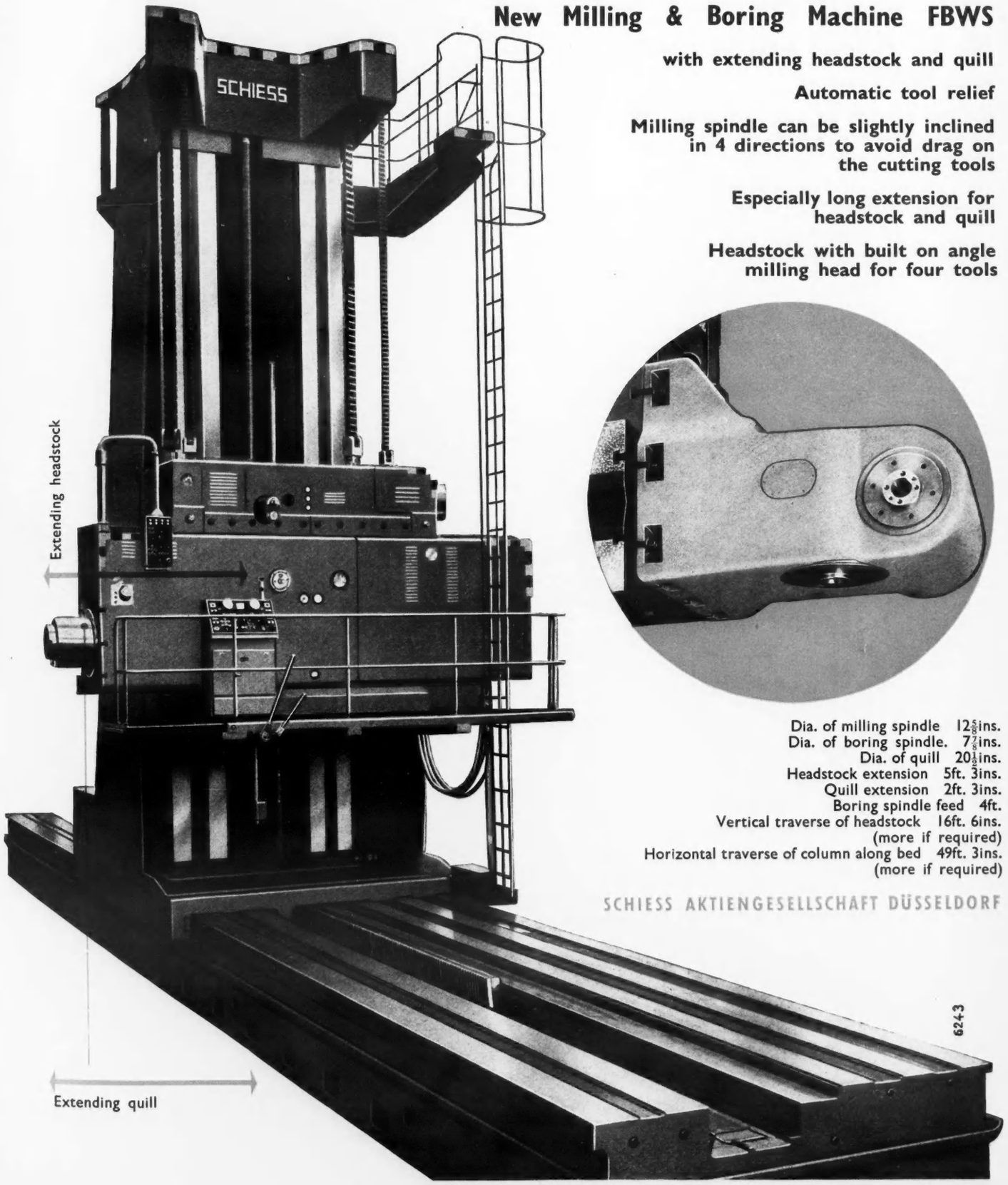

Dia. of milling spindle 12⅝ins.
Dia. of boring spindle. 7⅞ins.
Dia. of quill 20½ins.
Headstock extension 5ft. 3ins.
Quill extension 2ft. 3ins.
Boring spindle feed 4ft.
Vertical traverse of headstock 16ft. 6ins. (more if required)
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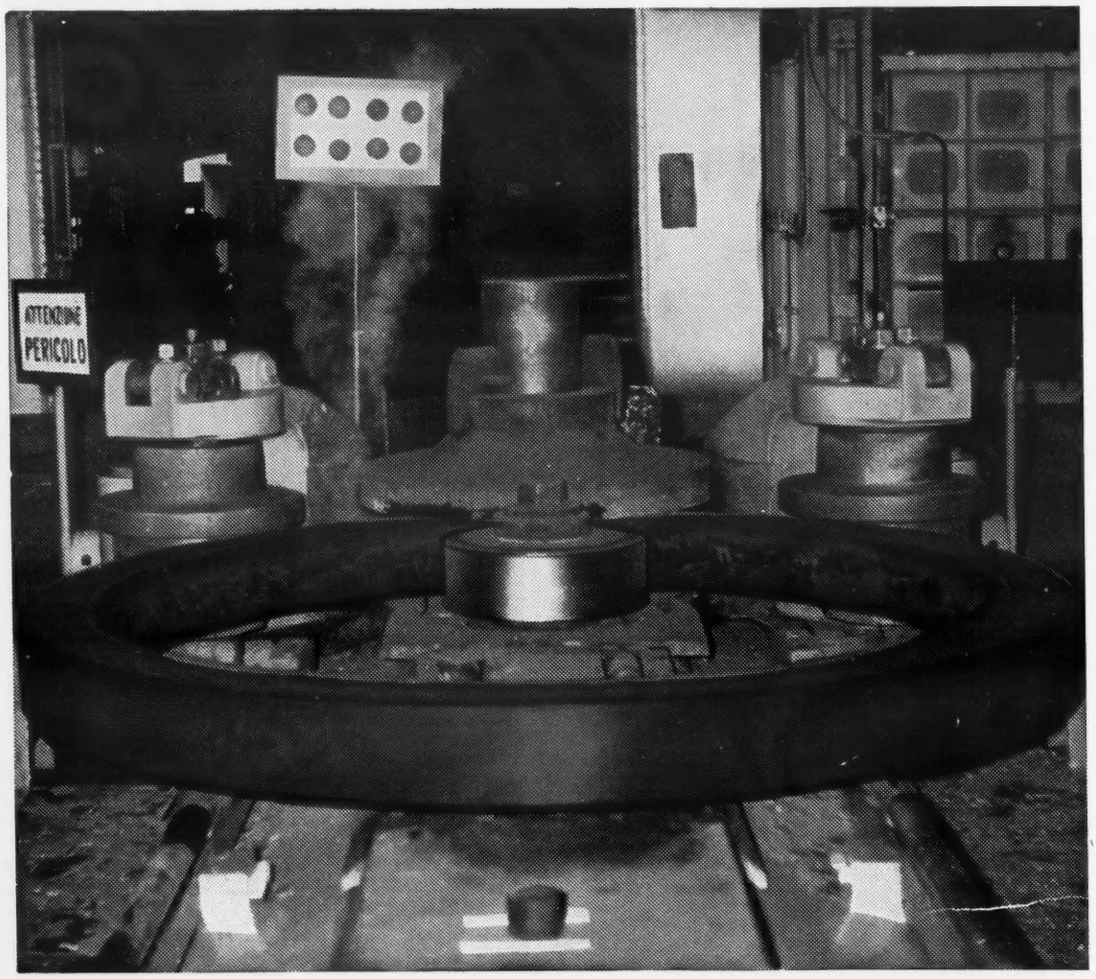

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NUCLEONIC BACKSCATTER TECHNIQUE

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"Developed in collaboration with British Insulated Callender's Cables Limited".
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The technique employed is a Beta backscatter measurement with fully transistorised circuit operating a moving coil meter. It is essentially a practical low-cost instrument for use by those responsible for the condition of galvanised tanks, pylons and similar steel structures.
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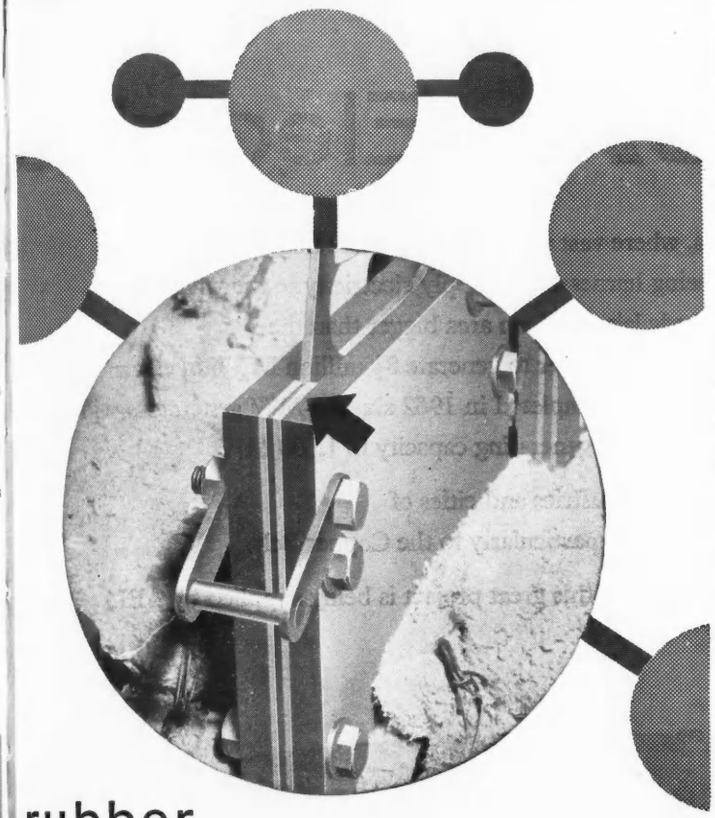

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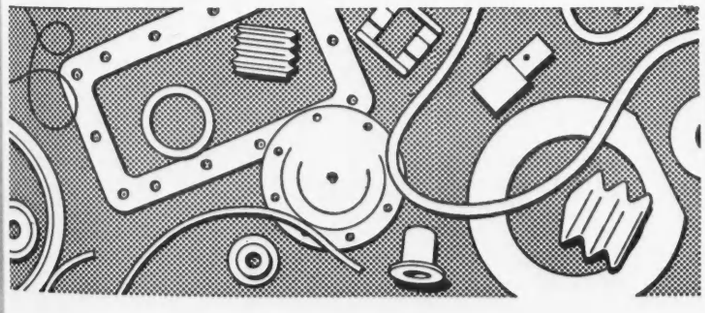

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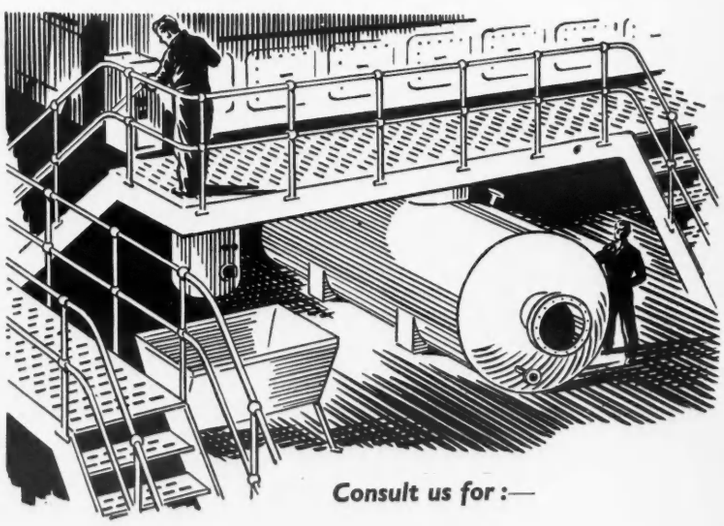

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KARIBA—Electrica

THREE HUNDRED MILES downstream from Victoria Falls, where vast power goes to waste in a magnificent display, the waters of the Zambesi are being harnessed to supply electricity to the whole of Northern and Southern Rhodesia. The world's largest man-made lake, with an area bigger than the whole of the county of Kent, will store sufficient water power to generate 8½ million MWh of electricity annually. When the first stage of the plan is completed in 1962 six 100-MW generators will be in operation. By the early 1970's it is planned to raise the total generating capacity to 1,500 MW.

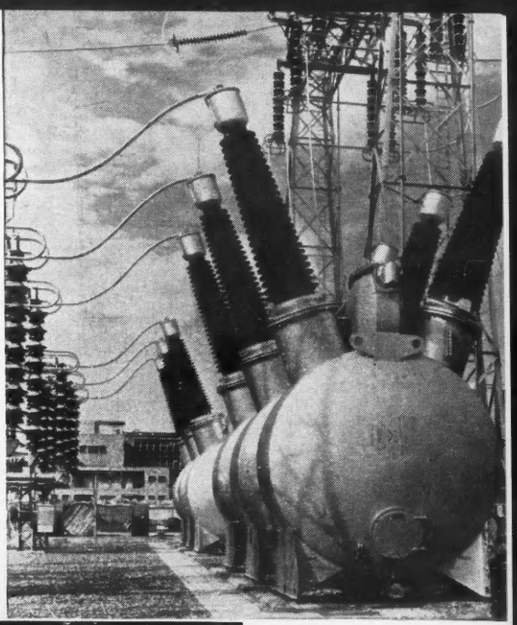
From Kariba this power will be distributed to the growing industries and cities of the Rhodesias and particularly to the Copper Belt.

Much of the major electrical equipment for this great project is being supplied by AEI.

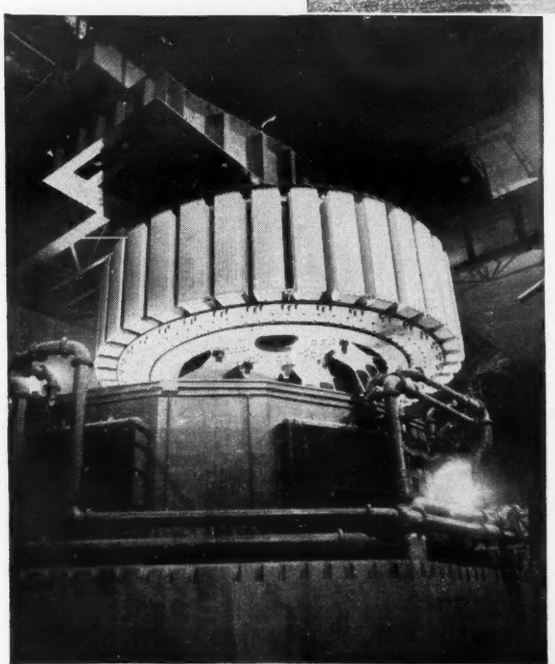
Partly assembled stator, showing foundations for thrust block.

Merz & McLellan–Electrical and Mechanical Consulting Engineers to the Federal Power Board.

Engineering on the Grand Scale



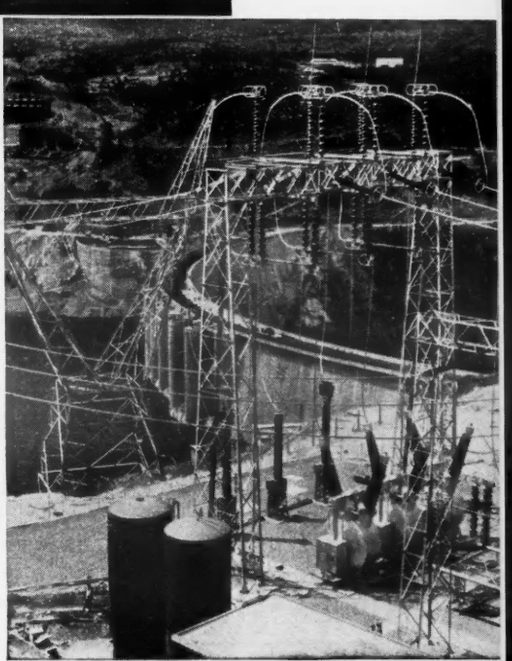
330 kV 7,500 MVA circuit breakers at Kariba switching station.



One of the six 100-MW generator rotors being lowered into its stator.

AT THE HEART OF THIS TREMENDOUS SCHEME are the six 100-MW AEI generators—the largest hydro-electric generators in Africa. Power is distributed at 330 kV which is the highest voltage to be used in the Southern hemisphere. For switching this power at Kariba and at the six sub-stations in Northern and Southern Rhodesia, AEI is to supply 25 oil circuit breakers, over 100 isolators and ancillary equipment.

AEI contracts also include the provision of 50 miles of cables, including control cables, co-axial and telephone cables and lead-covered cables for the underground power station.



A section of the 330-kV switchyard at Kariba showing the equipment to control the feeder to Lusaka and Kitwe in Northern Rhodesia. The dam can be seen below.

AEI

Associated Electrical Industries Limited

33 GROSVENOR PLACE, LONDON, S.W.1

AEI 211

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overhead travelling cranes

For overhead travelling cranes up to 90 ft. span and 10-ton capacity, cabin-controlled or floor-controlled, Acrow-Demag design and quality of workmanship cannot be surpassed.

Remember, also, that all Acrow-Demag motors are of the tapered-rotor, self-braking type, reducing brake maintenance to a minimum, and you will agree that in Acrow-Demag Overhead Travelling Cranes you have

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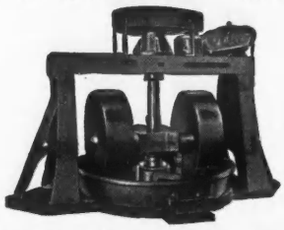

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HAMMERED OR HYDRAULIC PRESSED
FORGINGS
IN STEEL BLACK OR MACHINED TO 24 TONS

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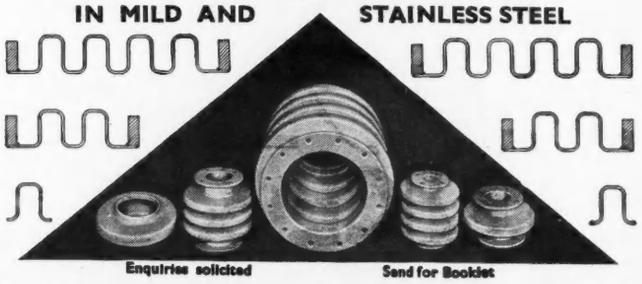
PRESSED STEEL BELLOWS TYPE
IN MILD AND STAINLESS STEEL



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also AIR RECEIVERS, CHIMNEYS, TANKS, PIPE WORK, PRESSURE CYLINDERS, AND FABRICATED STEEL PLATEWORK

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For magnified output . . .

use mechanical tubing . . .

A great deal of time, labour and materials are saved when mechanical tubing is used, particularly when manufacturing rollers and ring-shaped machined parts.
We carry large stocks of tubing in many sizes and lengths with either large or small diameters. They are available in various finishes and are obtainable suitable for machining.
Write for further details so that we may send you a booklet listing the varied types and sizes of tubes we stock.
IMMEDIATE DELIVERY IN MOST CASES.

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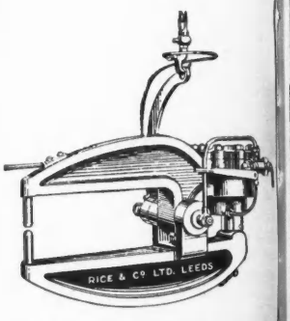
Pumps, Accumulators, Riveters, Presses for Flanging, Bending and Straightening, Deep Pressing, Lead Pipe Extrusion, Baling Steel Scrap, Wool, Cotton, etc.



HYDRAULIC HINGED RIVETER
1'-6" to 3'-0" Gap. 20 to 30 tons power.

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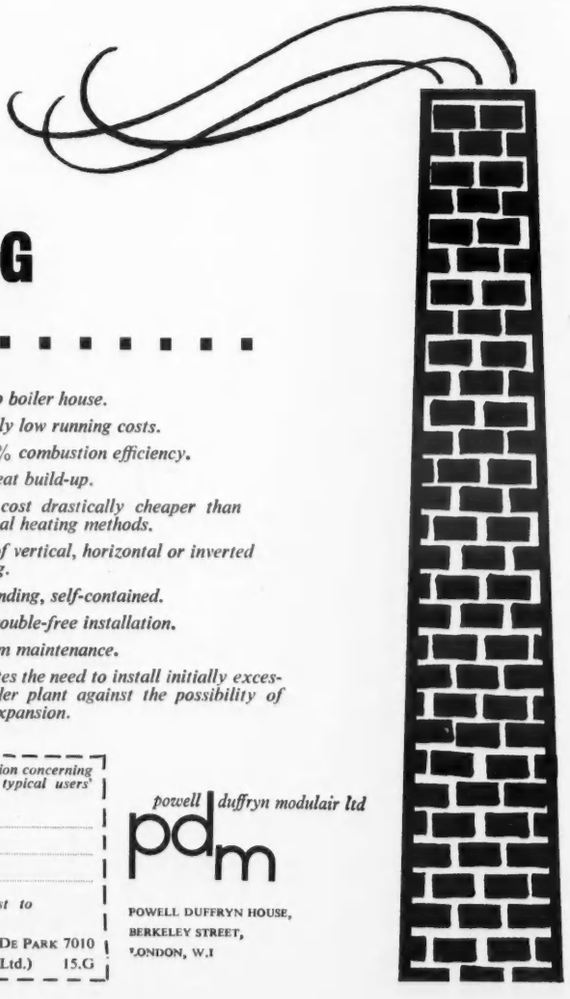
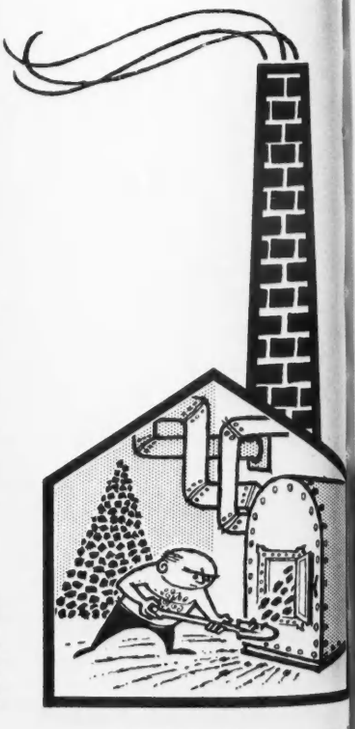
PERFECT HEATING WITHOUT THIS . . . . . .

. . . belching smoke stacks should not be with us today. Many managements have eliminated smoke stacks as part of an antiquated heating system – gone is the anguish and high cost of boiler house installation, the interference with production, the delay. Modern industrialists think Modern, and use Dravo. For the oil or gas-fired Dravo heater meets today's essential requirements of easy, low-cost installation, extreme simplicity of maintenance and economical running. When you consider the advantages listed, you will see why industry all over the country is turning to Dravo – the up-to-date solution to the problem of space-heating.

- ★ *Needs no boiler house.*
- ★ *Extremely low running costs.*
- ★ *Over 80% combustion efficiency.*
- ★ *Quick heat build-up.*
- ★ *Capital cost drastically cheaper than traditional heating methods.*
- ★ *Choice of vertical, horizontal or inverted mounting.*
- ★ *Free-standing, self-contained.*
- ★ *Swift, trouble-free installation.*
- ★ *Minimum maintenance.*
- ★ *Eliminates the need to install initially excessive boiler plant against the possibility of future expansion.*





DRAVO

Send me by return post full technical information concerning the Dravo Counterflo' Heater and a set of typical users' case histories.

NAME .....

ADDRESS .....

Please attach coupon to your company letterheading and post to

POWELL DUFFRYN MODULAIR LIMITED

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(Dravo is manufactured by Coventry Radiator and Presswork Co. Ltd.) 15.G

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POWELL DUFFRYN HOUSE,
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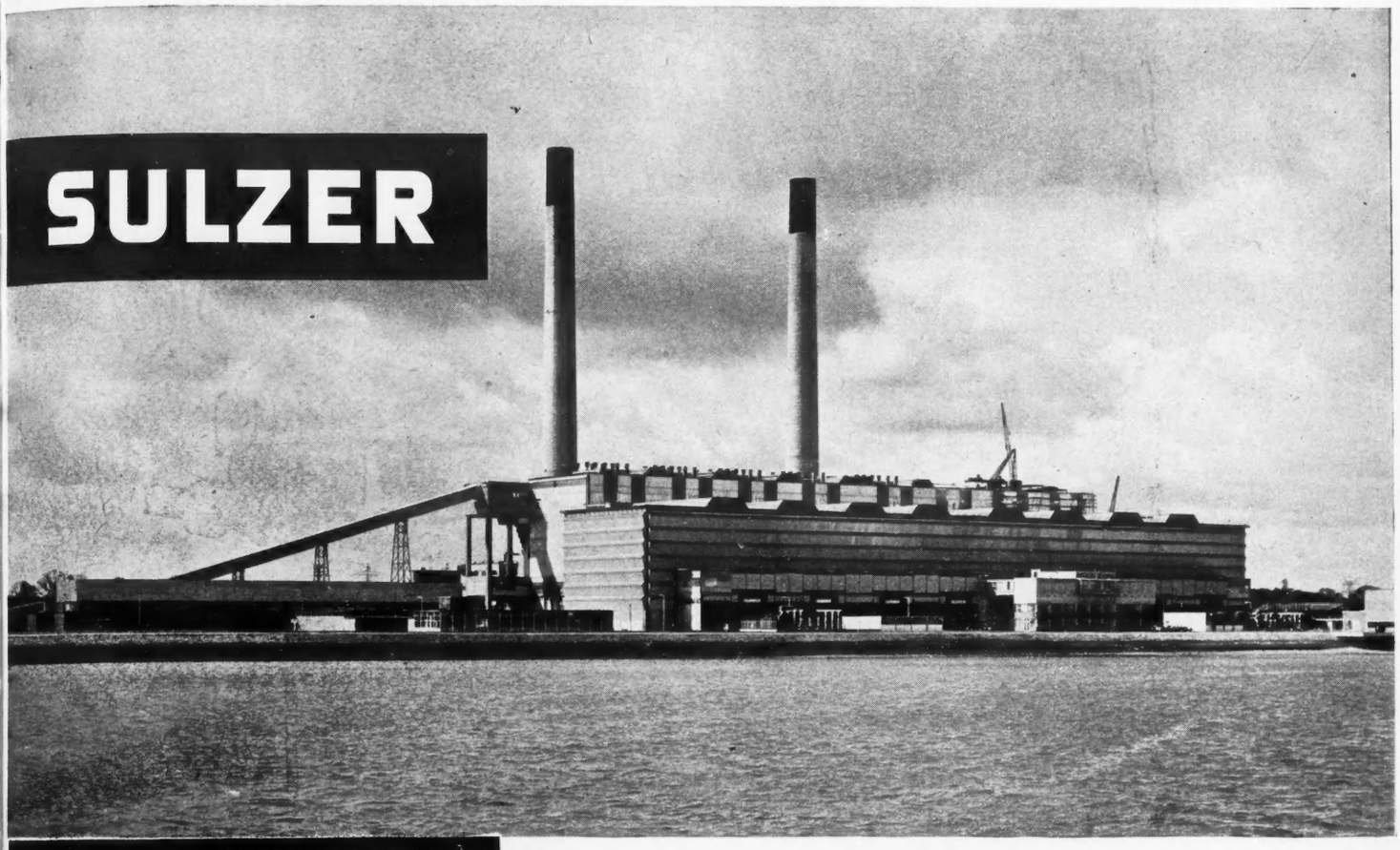
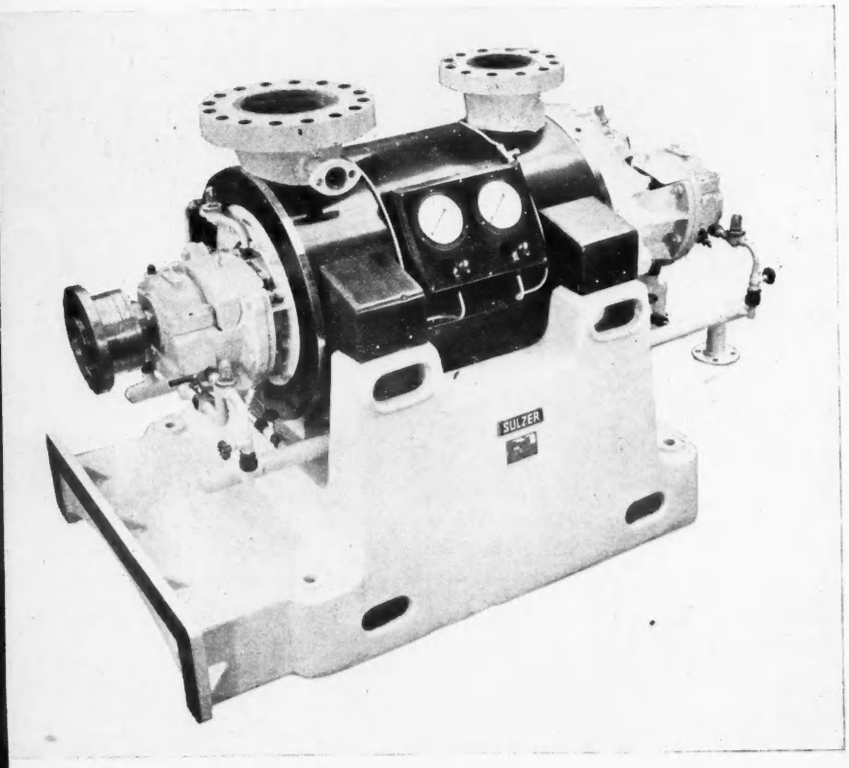
SULZER



Installed in the Marchwood Power Station for the Central Electricity Generating Board.

One of twelve electrically driven Sulzer Boiler Feed Pumps, each with a capacity of 650,000 lbs per hour, at a pressure of 1,242 lbs p.s.i. and a temperature of 260°F.

Complete range of Boiler Feed Pumps for Nuclear and orthodox Thermal plants including advance class units.



Telephone Museum 7890

SULZER BROS. (LONDON) LTD.,

Incorporating Hathorn Davey & Co. Ltd.

31 Bedford Square, London, W.C.1.

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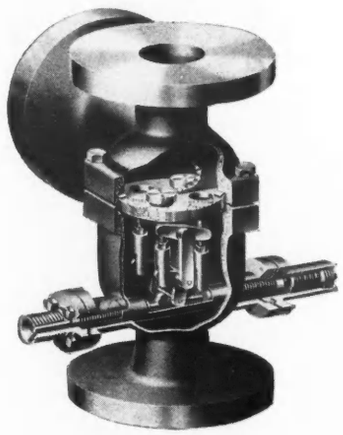
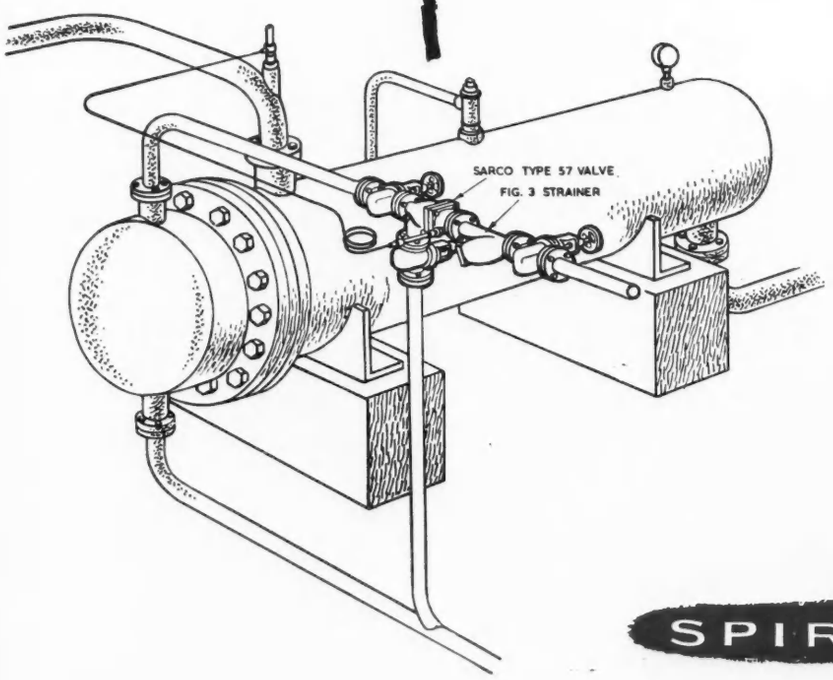
Automatic Control of Non-storage Calorifiers



The automatic temperature control of H.P.H.W. non-storage calorifiers can be safely left to the Sarco " Type 57 " diversion valve.
This 3-ported valve ensures a constant circulation and fully balanced conditions in service. This feature is welcome even in a single heat exchanger: it is of even greater consequence where two or more exchangers are being run in series. 3-ported operation also guarantees no temperature creep. Above all, the " Type 57 " ensures correct control with no attention and negligible maintenance.
It has been specifically designed to meet the particular problems of heating engineers.



The " Type 57 " valve, like the rest of the Sarco range, is entirely self-acting, with ample hydraulic power for its purpose. Its famous Sarco *packless* glands gives welcome freedom from leaks and maintenance troubles.

The 4-poppet valve mechanism (which can be lifted out complete for inspection) is fully balanced, and is not affected by changes of pressure and velocity. Flashing and waterhammer troubles do not arise, and the valve gives dead shut-off in the extreme position, preventing temperature creep.

Limits 350 p.s.i., 450° F., six sizes.

SPIRAX - SARCO

Please post . . . details and drawings of the Sarco 'Type 57' H.P.H.W. diversion valve.

EG 760

SPIRAX-SARCO LTD. CHELTENHAM PHONE 5173 GRAMS SPIRAX TELEX CHELTENHAM LONDON: 41 CURZON STREET, W.1 GROSVENOR 1671

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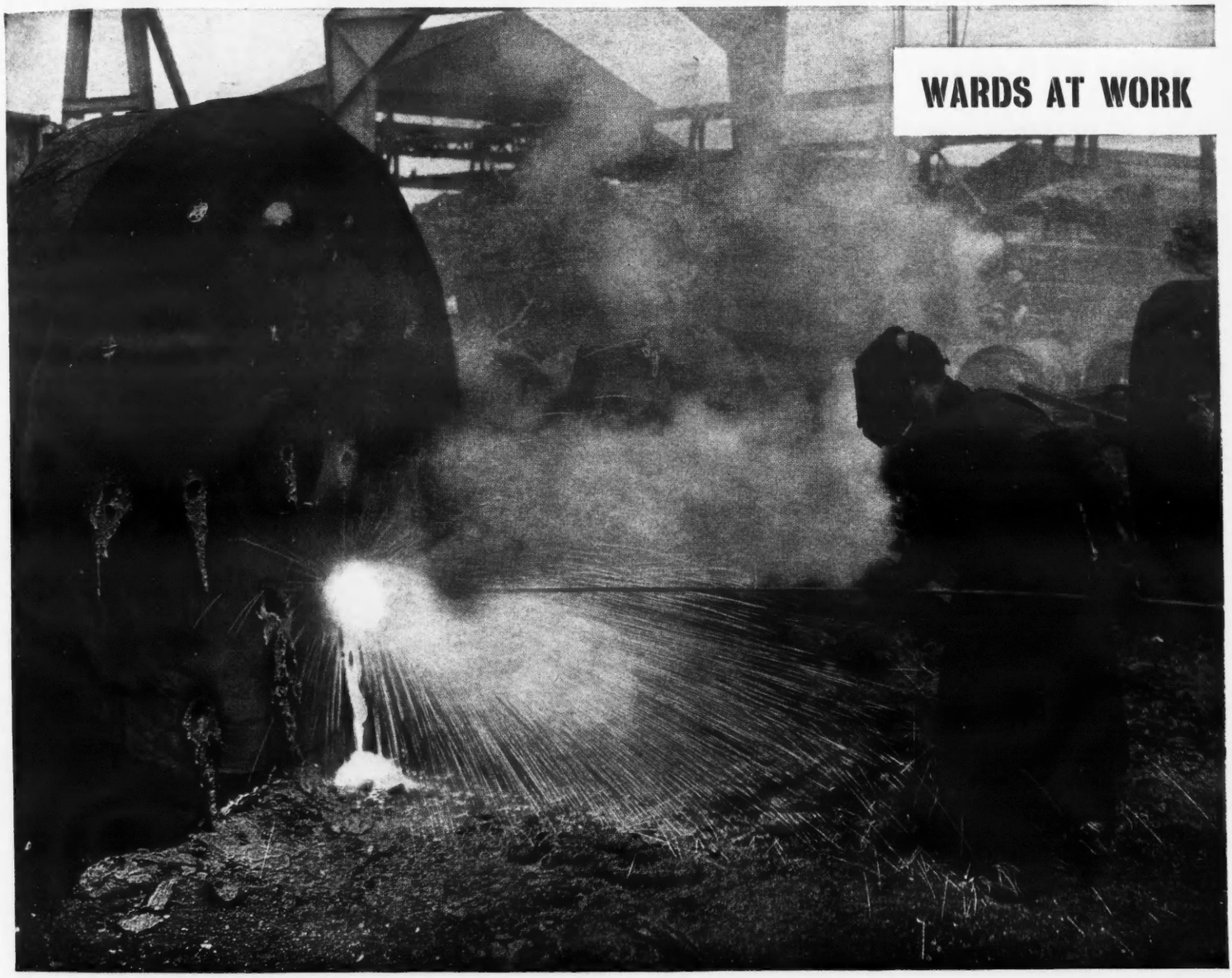

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GP 93

MAKING LARGE TIMKEN BEARINGS

This illustration, of part of the assembly department at our Daventry works, shows a variety of large bearings. The one shown partly in section in blue (full size) is 25½ ins. bore, 40½ ins. outside diameter, 22½ ins. wide. We have supplied this bearing for the past 21 years for the back-up rolls of a wide strip mill.

THE demand for large Timken tapered roller bearings has been growing steadily for over 30 years. To help to meet this demand, it was decided six years ago to build a new factory at Daventry for the manufacture of large bearings only, and this factory was very quickly in full operation.

Some Timken bearings exceed 7 feet in diameter, others weigh as much as 4½ tons.

British Timken, Duston, Northampton, Division of The Timken Roller Bearing Company. Timken bearings manufactured in England, Australia, Brazil, Canada, France and U.S.A.

TIMKEN®

REGISTERED TRADE-MARK

tapered roller bearings

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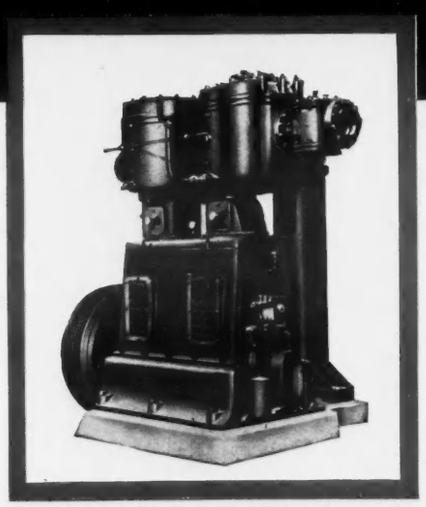
MEN WHO MAKE STEEL use "BROOMWADE" Air Compressors & Pneumatic Tools

Photograph by courtesy of United Steel Companies Ltd.



One of a number of "BROOMWADE" Type TS2X Air Compressors, delivering 1,000 c.f.m. each, installed at Appleby-Frodingham works.

Steel and yet more steel is the insatiable demand of industry.

In Britain's Steelworks and in Steelworks throughout the world, compressed air is being increasingly used. Modern compressed air equipment is a safe source of power. Safety and Reliability are essential factors in the production of steel and the increasing demand for "BROOMWADE" Pneumatic Equipment is indicative of its Efficiency and Reliability. In the well-known Appleby-Frodingham steelworks, "BROOMWADE" Air Compressors are playing an important part.

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AIR COMPRESSORS & PNEUMATIC TOOLS · YOUR BEST INVESTMENT

BROOM & WADE LIMITED, P.O. BOX NO. 7, HIGH WYCOMBE, BUCKS. TELEPHONE: HIGH WYCOMBE 1630 (10 LINES). TELEX: 83-127 796 SAS

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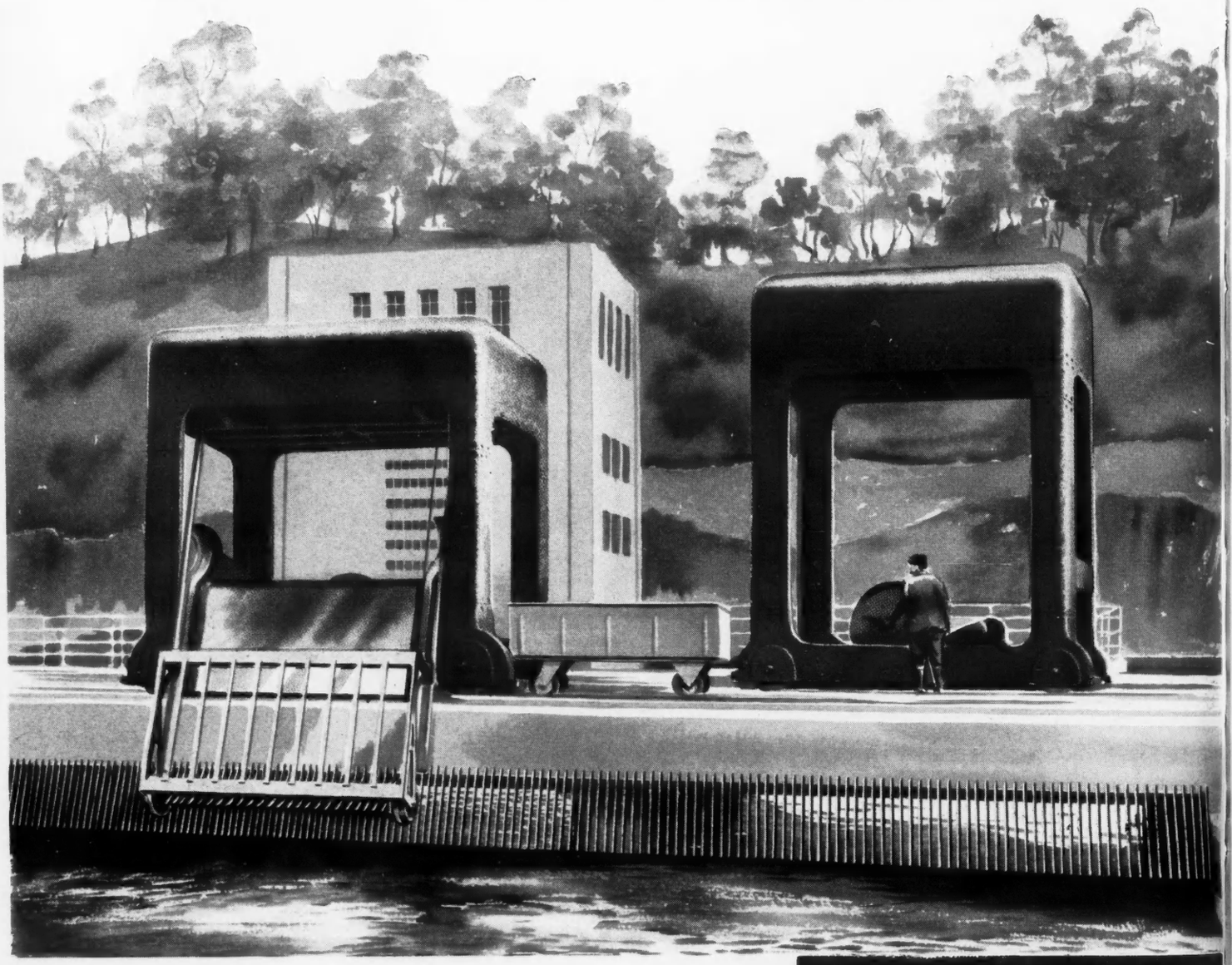
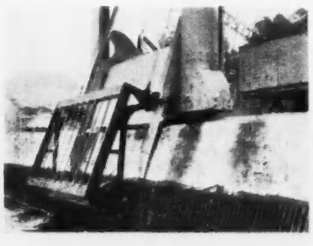
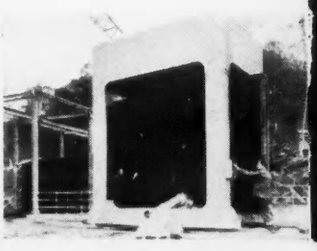
All types of

mechanical handling plant



. . . screens, trash rakes and cranes for hydro-electric intake works . . .





Strachan and Henshaw Ltd

STEELHOIST WORKS
BRISTOL 2 ENGLAND
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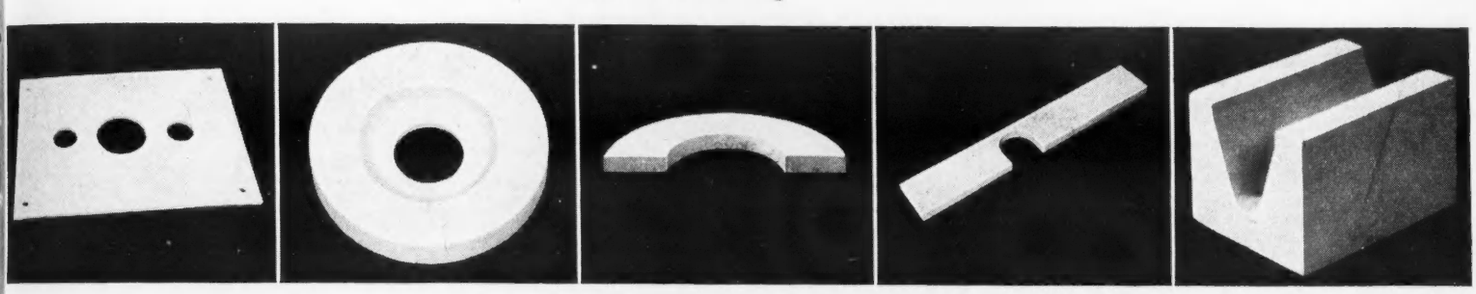
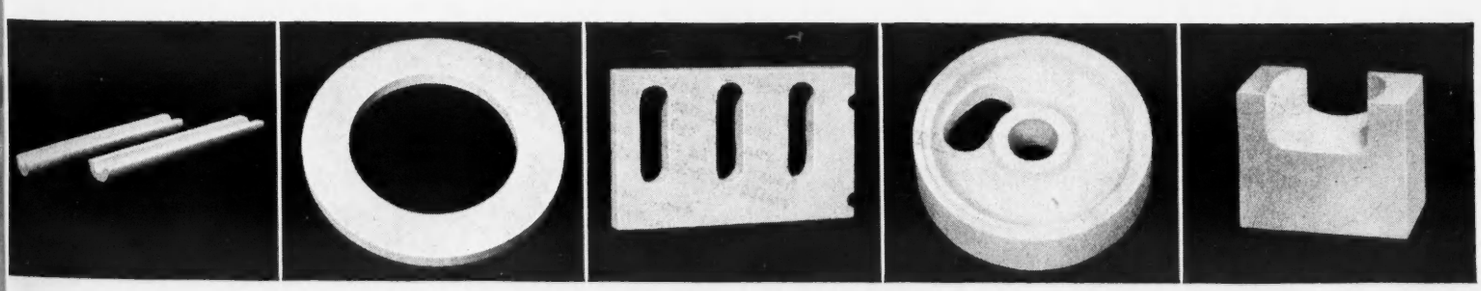
Each one of the objects
in this photograph is a machine part
from which is required a
specialised performance
combining:

Rigidity
Strength
Low thermal capacity
Non-combustibility
Chemical inertia
Machinability



we call them "specials"



Each has been machined in our factory
from flat Marinite sheet (up to 4 ins thick)
to a drawing provided by the user

can we turn one out for **you?**

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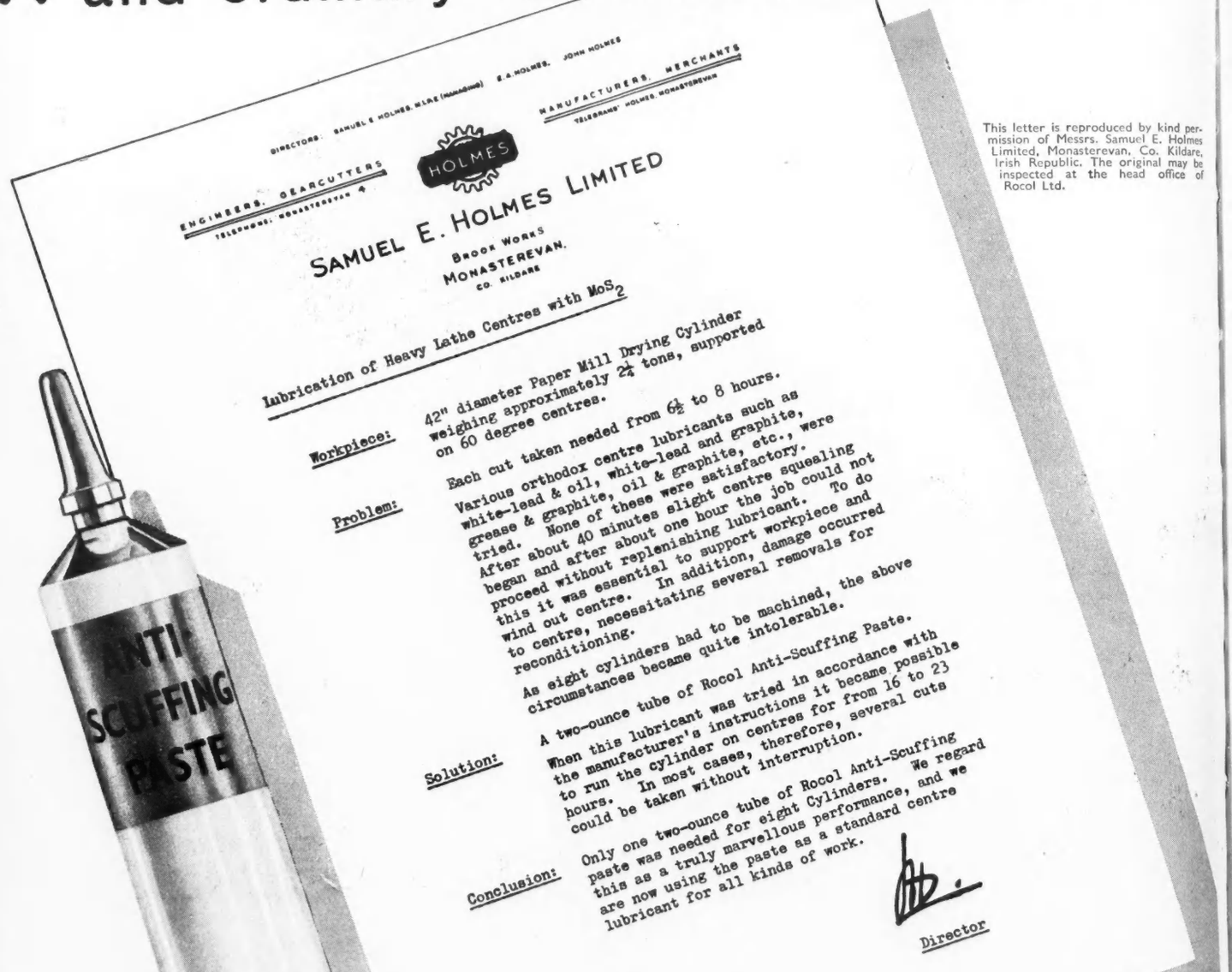
G

When hold-ups cost money...

... and ordinary lubricants have failed



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Lubrication of Heavy Lathe Centres with MoS_2

Workpiece: 42" diameter Paper Mill Drying Cylinder weighing approximately 2¼ tons, supported on 60 degree centres.

Problem: Each cut taken needed from 6½ to 8 hours. Various orthodox centre lubricants such as white-lead & oil, white-lead and graphite, grease & graphite, oil & graphite, etc., were tried. None of these were satisfactory. After about 40 minutes slight centre squealing began and after about one hour the job could not proceed without replenishing lubricant. To do this it was essential to support workpiece and wind out centre. In addition, damage occurred to centre, necessitating several removals for reconditioning.

As eight cylinders had to be machined, the above circumstances became quite intolerable.

Solution: A two-ounce tube of Rocol Anti-Scuffing Paste. When this lubricant was tried in accordance with the manufacturer's instructions it became possible to run the cylinder on centres for from 16 to 23 hours. In most cases, therefore, several cuts could be taken without interruption.

Conclusion: Only one two-ounce tube of Rocol Anti-Scuffing paste was needed for eight Cylinders. We regard this as a truly marvellous performance, and we are now using the paste as a standard centre lubricant for all kinds of work.

Director

March 1960

ANTI-SCUFFING PASTE

A Rocol PRODUCT

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Rocol ANTI-SCUFFING PASTE

... is the answer!

ROCOL MOLYBDENISED LUBRICANTS

are manufactured by

ROCOL LIMITED, General Buildings, Aldwych, London, W.C.2. Tel: HOLborn 1985

Rocol House, Swillington, Leeds. Tel: Garforth 2261

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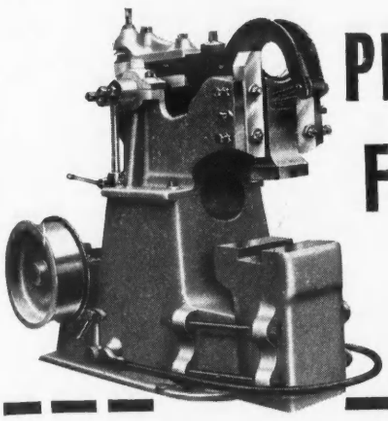
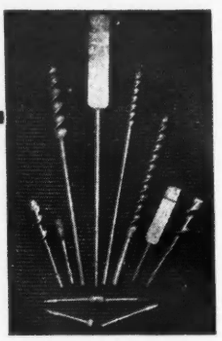
HIGH SPEED— PRECISION FORGINGS





275/300 blows per minute. Average size of work 1¼" bar. Adjustable stroke and guides. Rubber cushioned overhead motion. Loose Anvil Block. Separate motor stand available. A typical example of the type of work accomplished on this machine (illustrated right). For High Speed Precision Forging—the Model '100' POWER HAMMER.

SAMUEL JELLYMAN LTD

CANNOCK FOUNDRY & ENGINEERING WORKS
CANNOCK · STAFFS

TELEPHONE — TELEGRAMS: CANNOCK 2188

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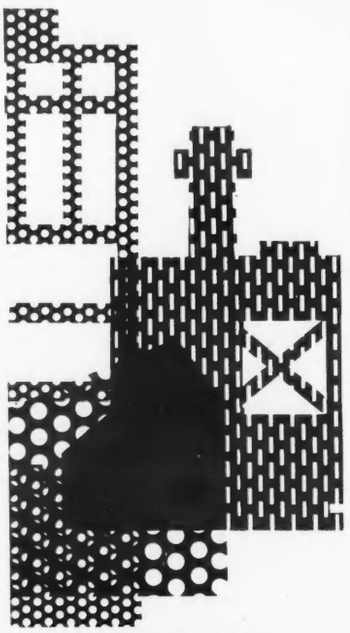

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We supply
COMPLETE PLANT
for
Waste Recovery
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Effluent Treatment

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DESIGNERS AND SUPPLIERS OF ALL PROCESS PLANT

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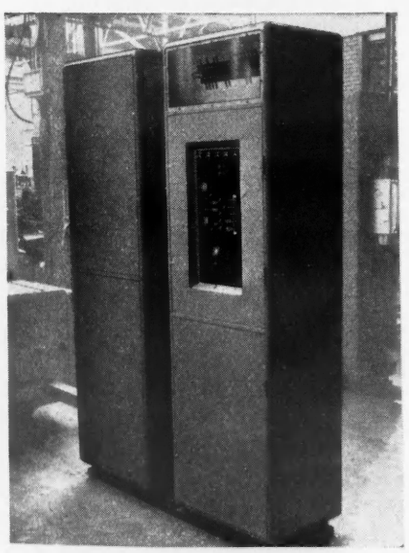
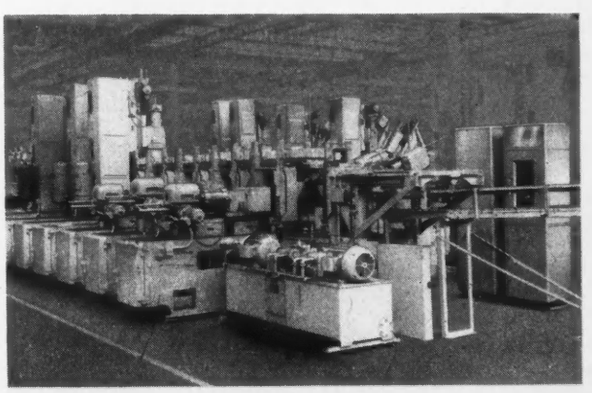


MASTER CONTROL CUBICLE

'ACCESS'

Austin Cold-Cathode Electronic Switching System, made under licence from the Austin Motor Co. Ltd., and Hivac Ltd.

ACCESS, a static switching system using Cold-Cathode Tubes, possesses the advantage of self indication.



TYPICAL APPLICATION—METALWORKING TRANSFER MACHINE

This control system is suitable for many applications including complex machine tool and conveyor installations. Write for Technical Literature.

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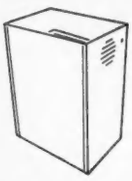
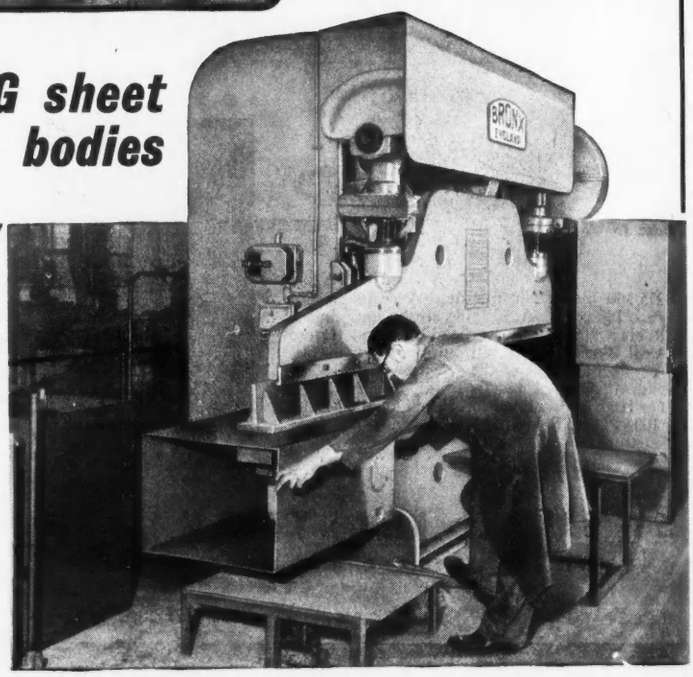
PRESS BRAKES

BRONX

Press Brake TOOLS



Seam locking on 22 SWG sheet Spin Dryer bodies



For making sharp bends in dead straight lengths — and for forming section in all metals, in all thicknesses up to 20 ft. wide — Bronx Press Brakes are faster and more versatile than folding machines. They can be tooled for seam-locking, punching, shearing and notching, etc.

Range of sizes from 10 to 10,00 tons pressure.

Illustration right shows 40-ton Bronx Press Brake (with Horn attachment) at C & C Products Ltd., Merton Abbey, London, S.W., makers of the Drial Major-Spin Dryer. The operation shows seam-locking body-front to body-back.

No matter what make of Press Brake you use, our FREE TOOL SERVICE is at your disposal.
Send for explanatory leaflet.
Large stocks of Tools are held for immediate despatch.

Tel: LYE 2307 & 2308

BRONX ENGINEERING CO. LTD., LYE, WORCS.

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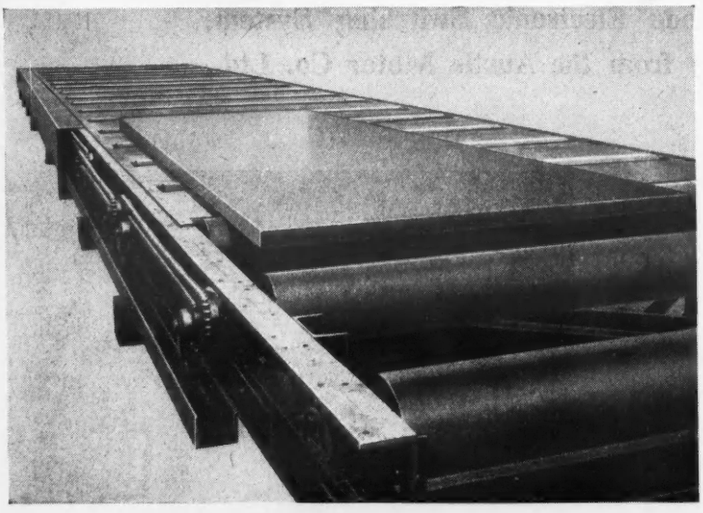
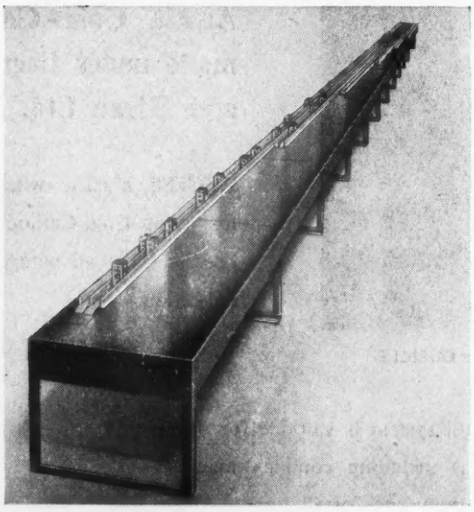
Conveyors by WESTWOOD DAWES

Ten Tons of Steel! OR A Quarter of Tea AND MOST THINGS IN BETWEEN!





are carried on:—

WESTWOOD DAWES

Troughed Belt Conveyors

Flat Belt Conveyors

Slat Conveyors

Scraper Conveyors

Gravity Roller Conveyors

Powered Roller Conveyors

Elevators, etc. etc.

WD

These photographs give an idea of the wide range of our products and the variety of applications for which they are specially designed.
Left: A heavy duty, powered roller conveyor carrying 2in. thick steel plates.
Right: A 100ft. long conveyor with twelve separate belts carrying ¼ lb. packets of tea.

WESTWOOD DAWES & CO. LTD.,
BOWLING GREEN ROAD · STOURBRIDGE · WORCS.
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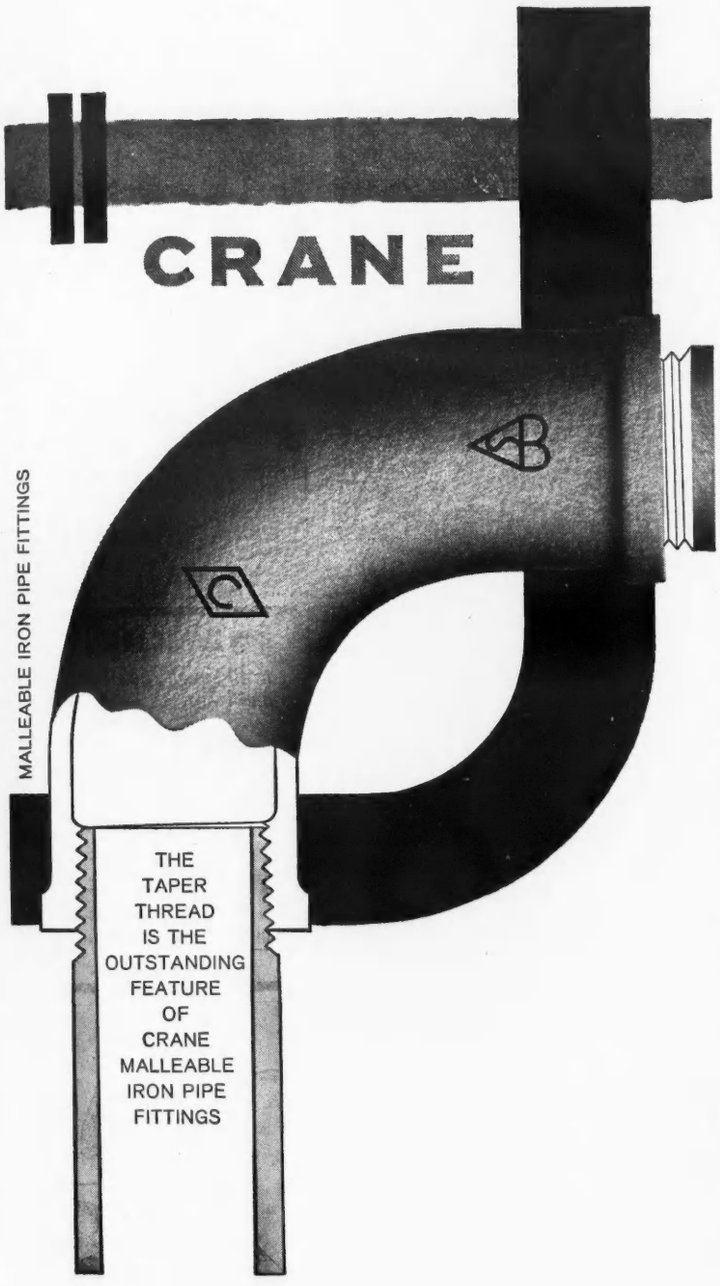

This joint is pressure tight, clean and sound. Above all, easy to make. The secret? It is made with the taper threads of a Crane Malleable Iron Pipe Fitting, manufactured to British Standard 143. All joints made with Crane Malleable Iron Pipe Fittings are easier to make pressure tight, besides eliminating the need for hemp packing.

Individually pressure tested

All Crane Pipe Fittings are inspected during manufacture and individually pressure tested at the Crane factory where they are made. That is why they give such long, trouble-free service.

Full range of types and sizes

Crane Pipe Fittings, both plain and banded patterns, are made in many types and sizes ranging from ⅛-inch to 6-inch, equal and reducing. Galvanized finish is also available. For full details, please write to the address below.

Crane Ltd., 15-16 Red Lion Court, Fleet St., London, E.C.4.
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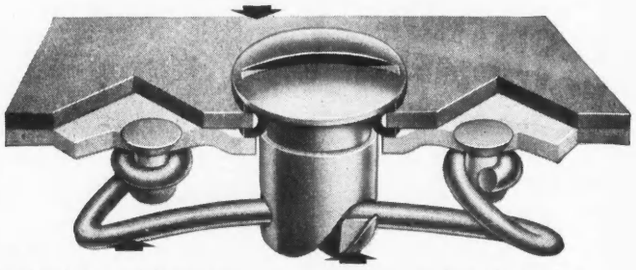
the fastest fastener

The locked position. The Dzus Fastener is instantly unlocked by a quarter turn anti-clockwise.



Steel spring mounting lends great strength and guards against loosening, however intense the vibration.

Cam operation ensures smooth easy working yet unbreakable grip; fastener supplied to suit any thickness.

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- Dzus are fasteners with a world reputation for reliability. They can be fitted quite simply in any solid or laminated material regardless of thickness.
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DZUS FASTENER EUROPE LTD.
Farnham Factory Estate, Guildford Road, Farnham, Surrey.
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A NEW TRAP BY AN OLD MAKER
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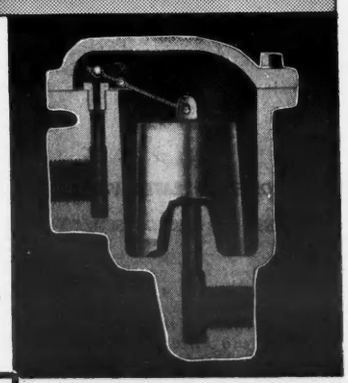

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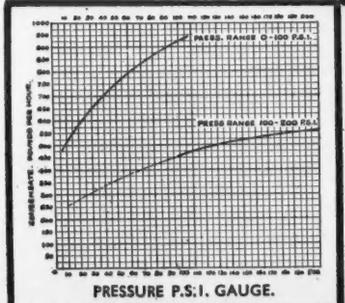

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Graph opposite shows maximum continuous discharge at 10 deg. F. below steam temperature of ¾in. and 1in. trap. ½in. trap approximately half the discharge shown.

For further details ask for list No. 98.

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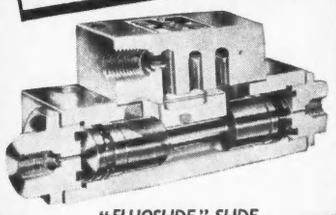

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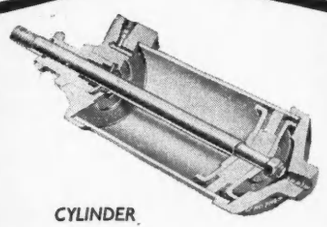
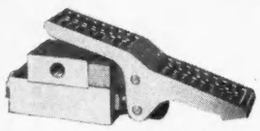
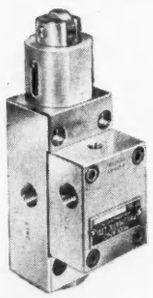


CYLINDER



FOOT CONTROL VALVE



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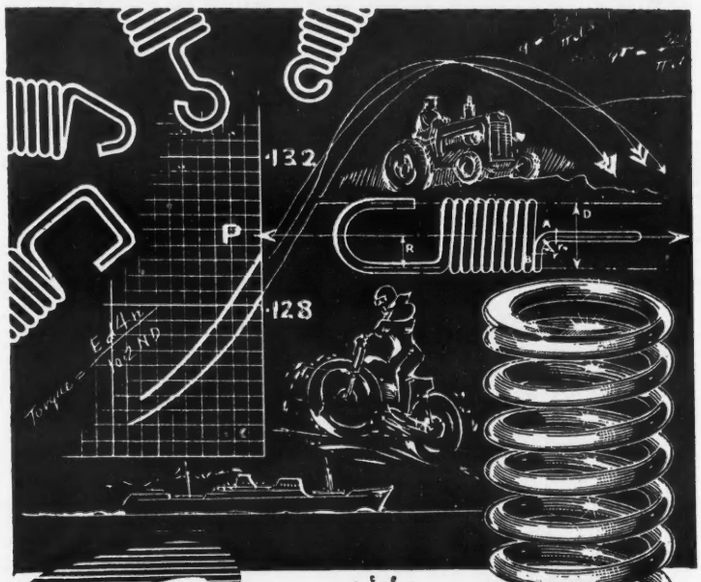

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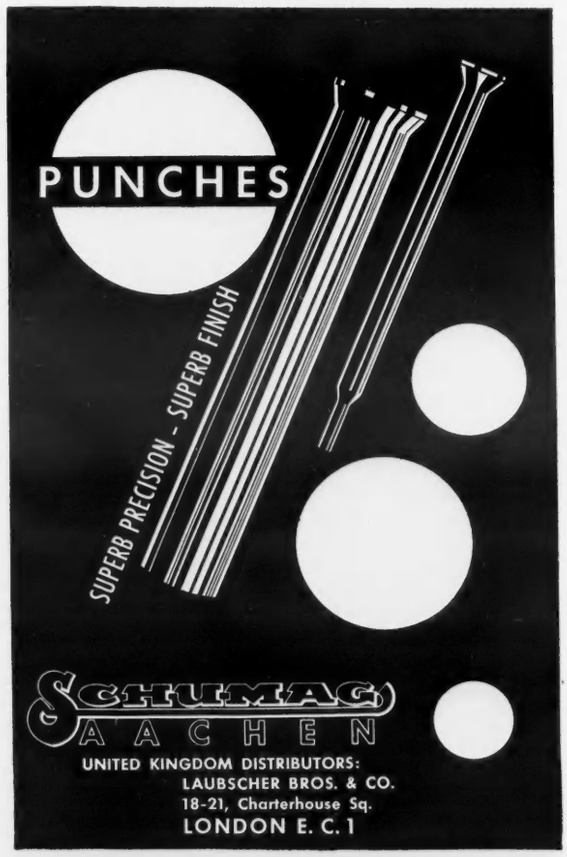

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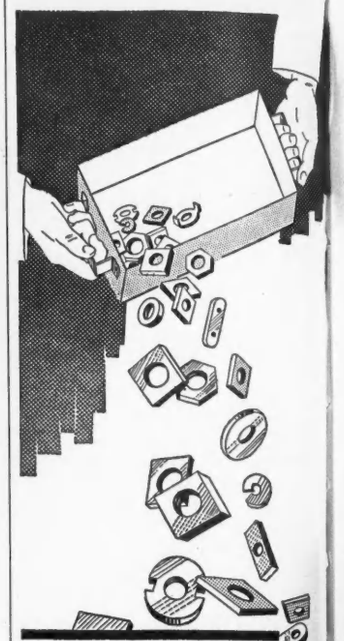

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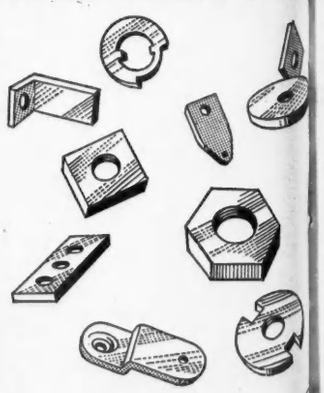

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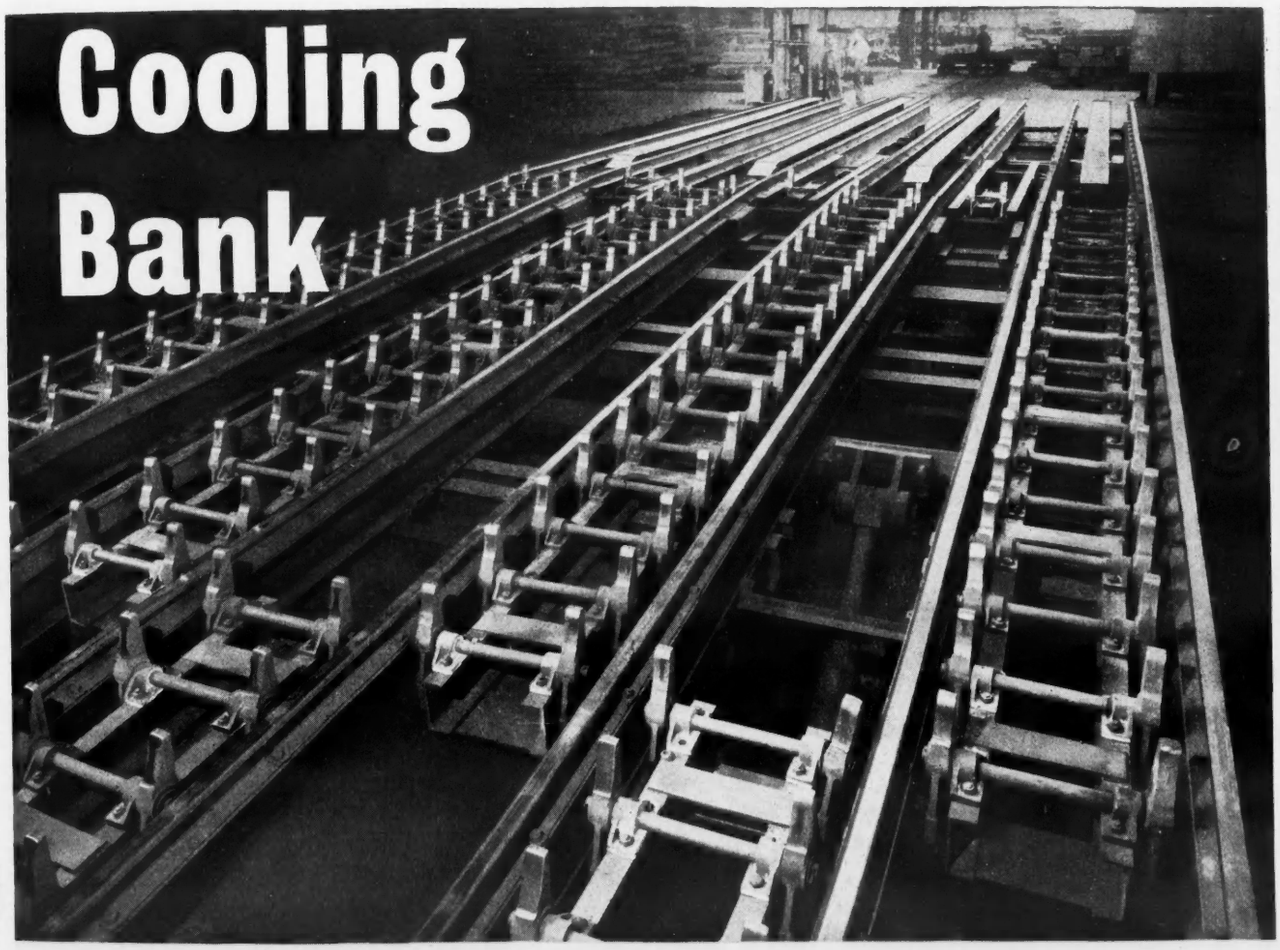
Photograph by kind permission of the Park Gate Iron & Steel Co Ltd



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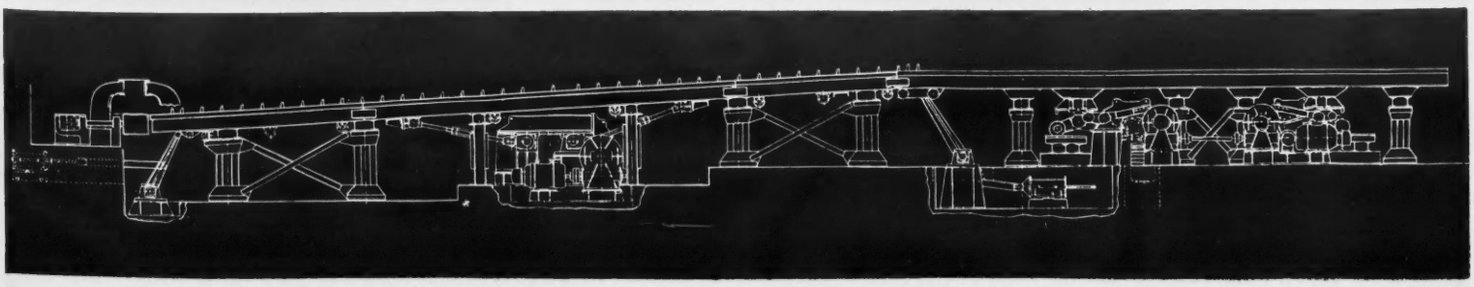

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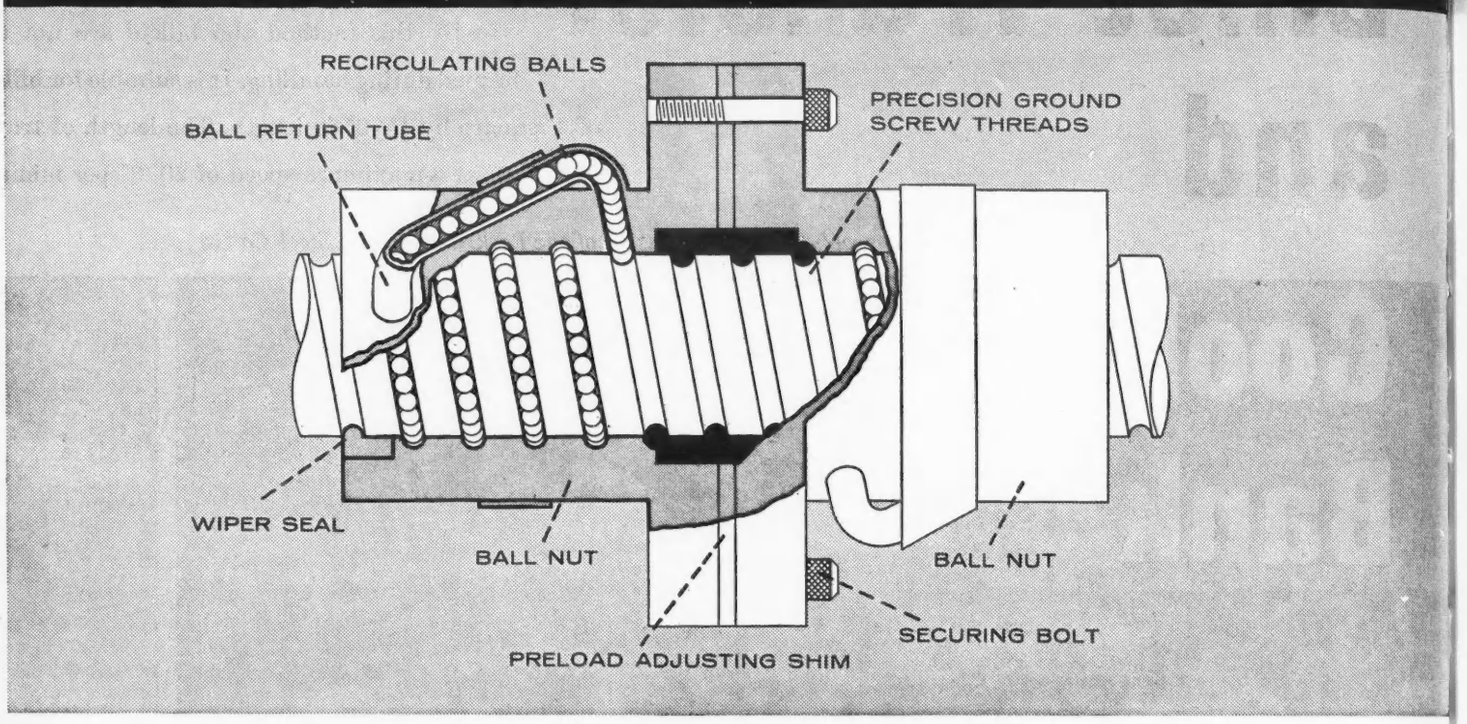

...ANOTHER ENGINEERING ADVANCE FROM BRISTOL SIDDELEY

Bristol Siddeley Engines Limited produce Beaver* pre-loaded ball screws. These ball screws achieve a minimum efficiency of 90% and they can operate within a temperature range of —52° C to 400° C without lubrication, and up to 170° C when lubricated.

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Basic design application analysis

Bristol Siddeley engineers make an exhaustive analysis of each specification. And each unit is specially designed for its particular application. Beaver ball screws are made automatically reversible or with controlled "no-back," with multiple or single circuits. Beaver pre-loaded ball screws have been proved as the most efficient method of converting rotary into linear thrust in over 2,700 engineering applications in many branches of industry. They have been designed already with rated operating load capacities of 370,000 lb (825,000 lb maximum static load) but the maximum potential operating load is, in most cases, limited only by the requirement.

Bristol Siddeley Beaver ball splines have been developed to eliminate the disadvantages of conventional splines. The designs are very effective in minimising friction, particularly when high torsional and bending loads are imposed during linear movement.

* *Complete technical and manufacturing co-operation with Beaver Precision Products Inc, Detroit.*

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J. B. STARKY, SALES MANAGER (BEAVER PRODUCTS DIVISION), BRISTOL SIDDELEY ENGINES LIMITED, PO BOX 17, COVENTRY, ENGLAND.

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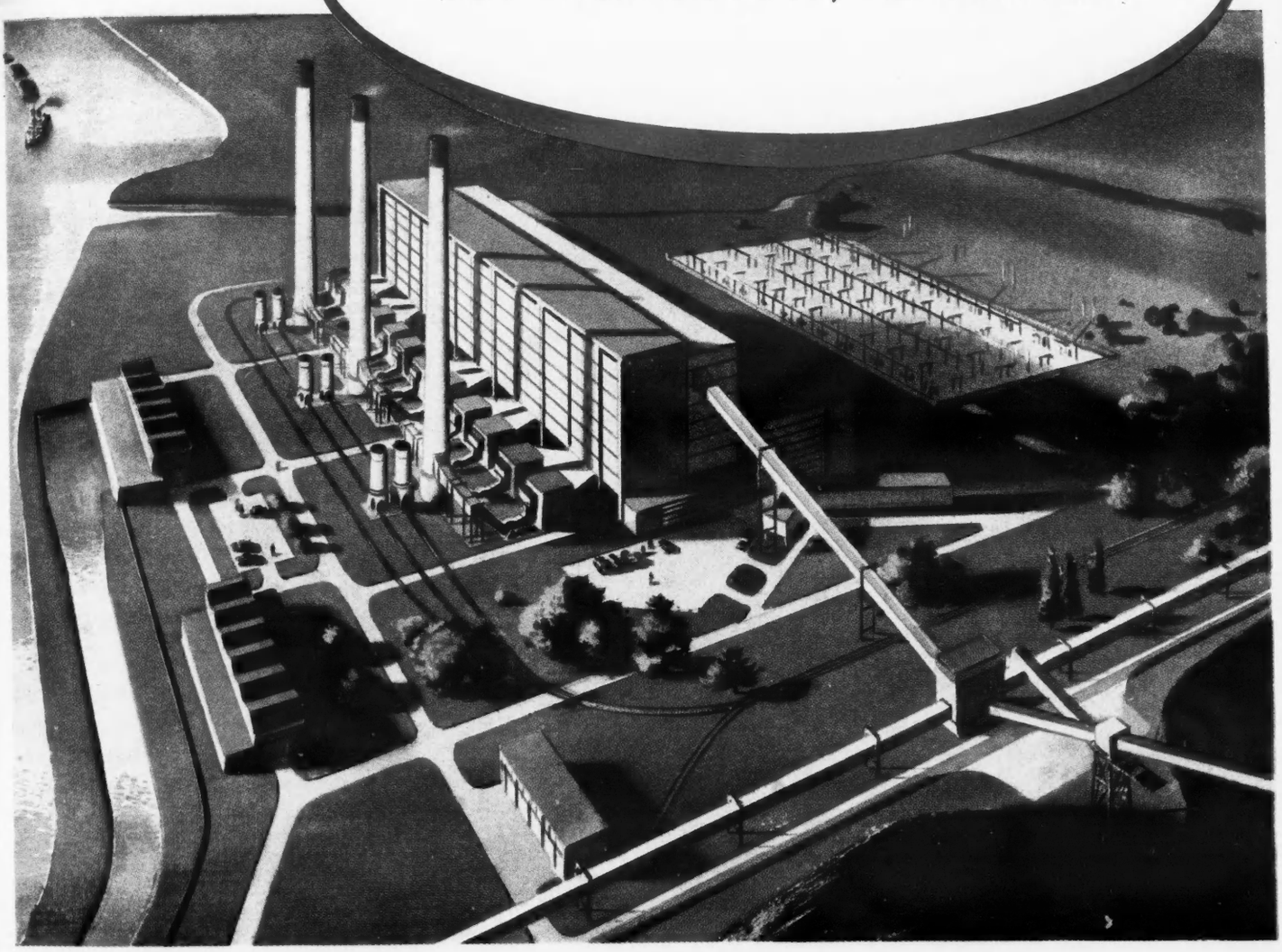

From an original drawing supplied by the Hydro Electric Power Commission of Ontario

THIS artist's impression shows the Lakeview Generating Station now being built beside Lake Ontario. With its planned capacity of 1,800 MW, it will be one of the world's largest thermal-electric plants. Two 300 MW turbine-generators have been ordered from AEI and the first will be installed in 1963. These generating sets, like all AEI equipment, will incorporate advanced design based on long experience.

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For further details, write to AEI Turbine-Generator Division, Trafford Park, Manchester 17, or to your local AEI Office

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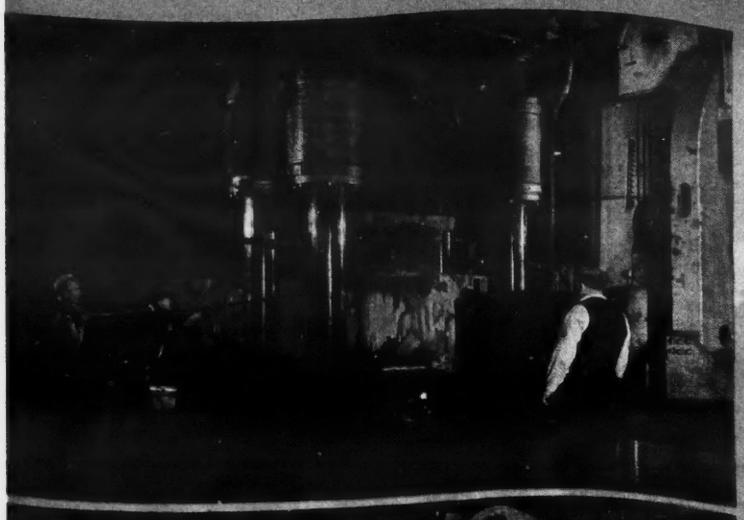

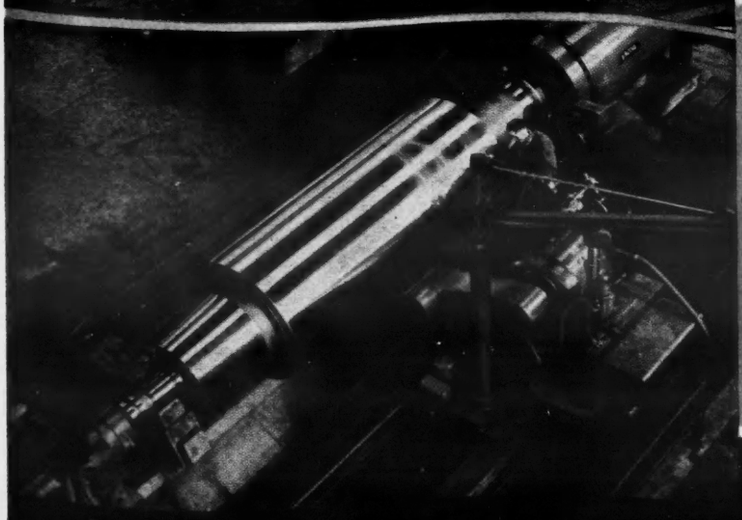

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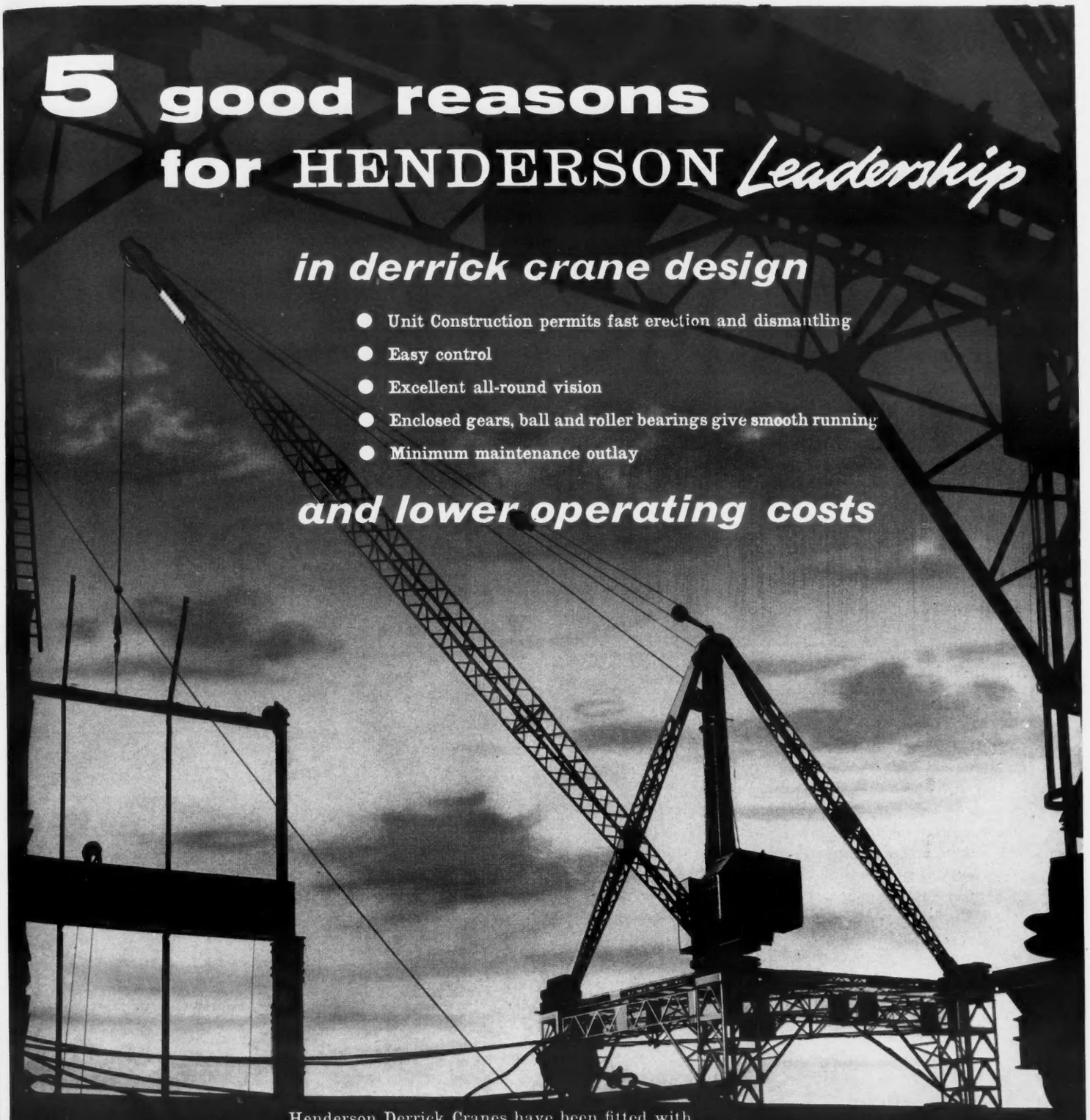

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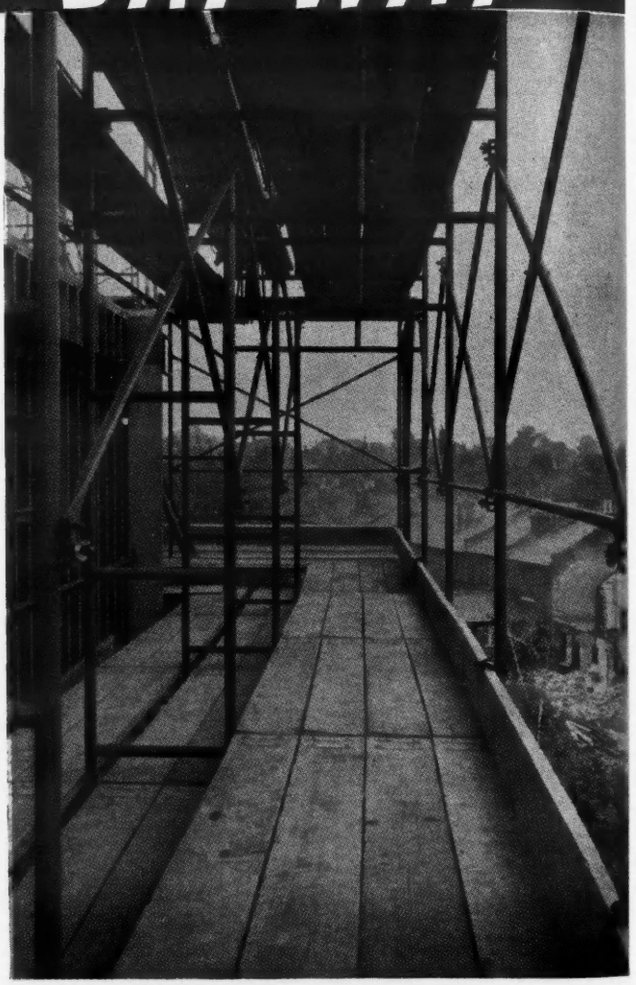

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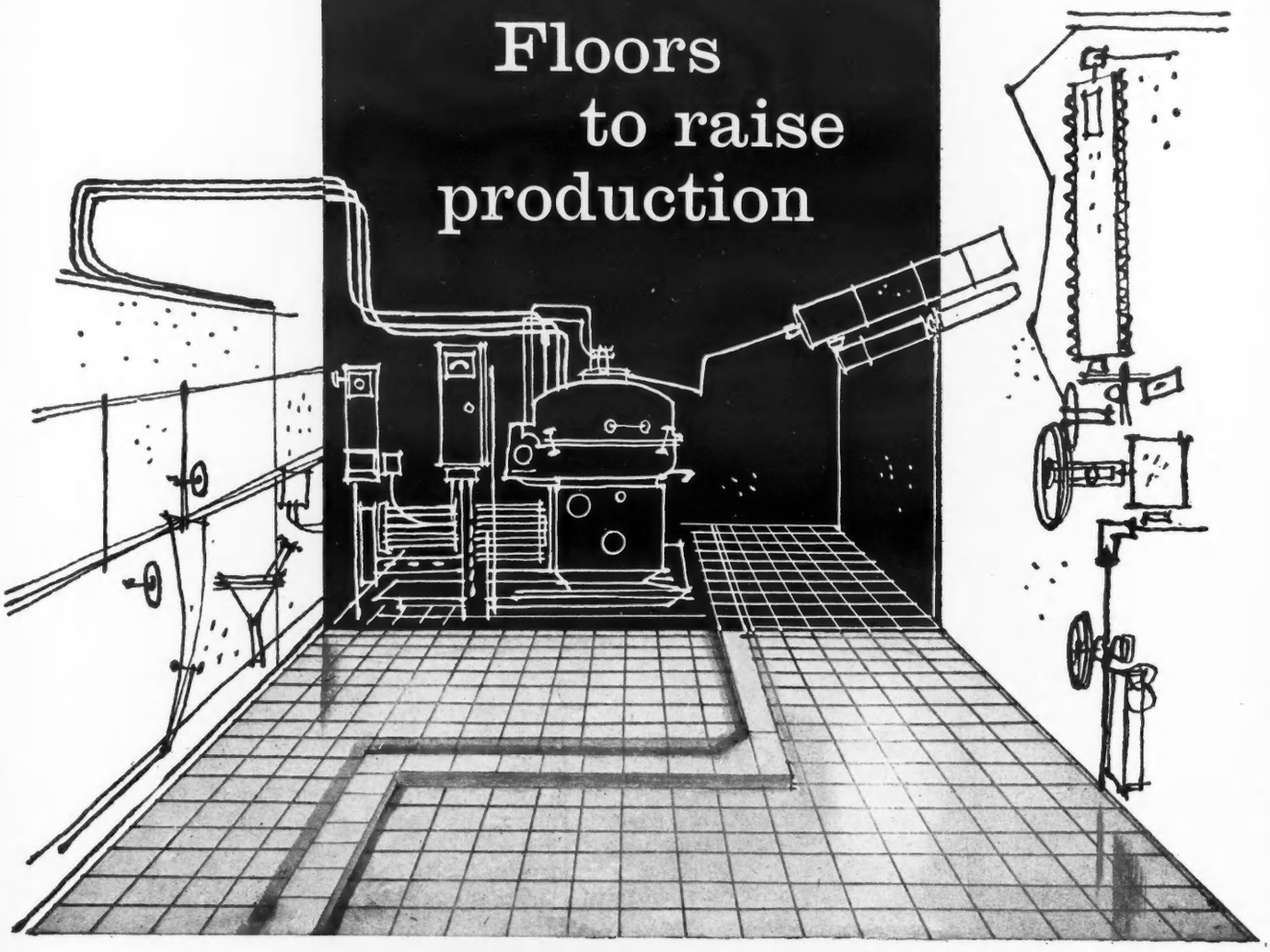

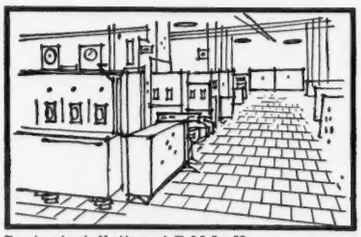

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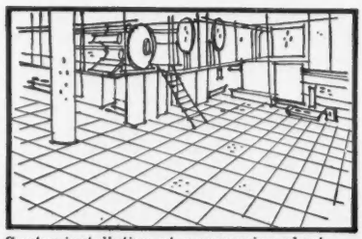

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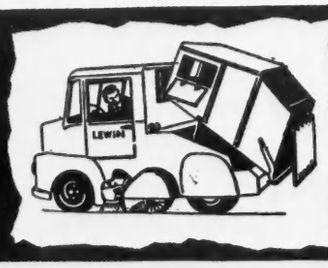

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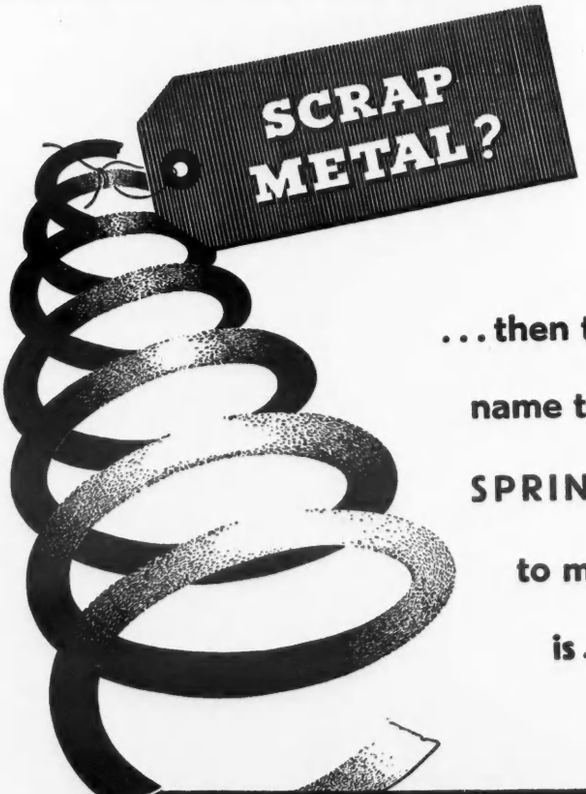

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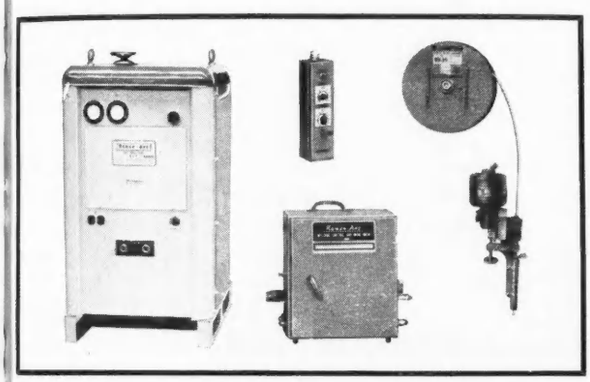

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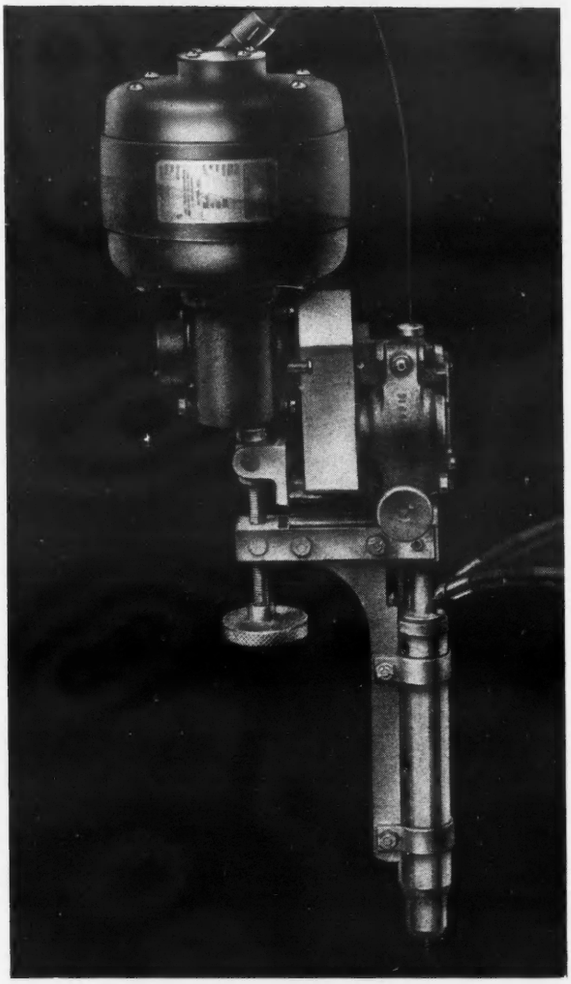

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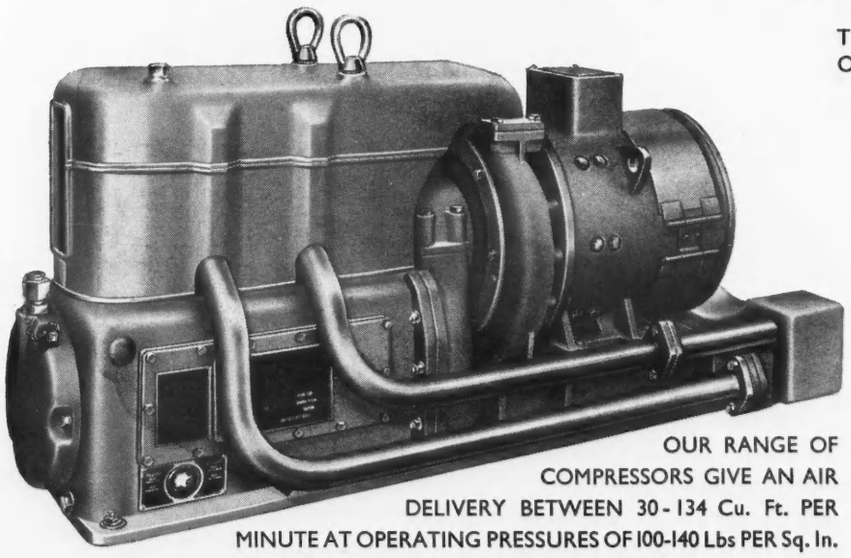

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keeps **Bowaters** in the news

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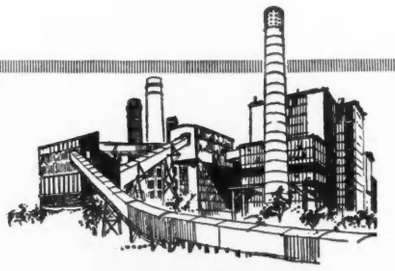
They chose coal because coal, mechanically stoked, provides the maximum heat at lowest cost. Furthermore, modern coal burning equipment is smokeless, and our coalfields can produce—for generations to come—*all* the coal that British industry will need.

The next time you are working out your fuel problems, remember Bowaters. For their pulp and paper mills in Kent and Cheshire they chose coal—one of the factors that point to a buoyant future at Bowaters. The same decision made by you may well begin a success story that could make headline news—on Bowaters' newsprint.

PROGRESSIVE INDUSTRY IS GOING FORWARD ON

COAL



POLICY INTO PRACTICE AT BOWATERS' KEMSLEY POWER PLANT

Mr. L. A. Robey, Deputy Power Engineer, comments:

"For many years we have operated our old boilers on coal and they have given long and satisfactory service.

The new pulverised fuel boiler which is designed for a continuous evaporation of 450,000 lbs/hr. at a pressure of 1,550 p.s.i.g. and a final steam temperature of 925°F. has steamed on coal from its commissioning date. The test efficiency obtained at full load was over 88% and this has been maintained consistently over long periods of operation with very high availability. The boiler stays very clean and with nominal maintenance excellent combustion conditions are maintained. The remote control is very flexible and meets the changing process demand without difficulty. Grit arresters collect the dust and discharge it automatically for disposal with the minimum amount of trouble.

The quality of fuels received has always been consistent and we have never failed to maintain the large stock piles which are required for the plant.

Bowaters' chose coal many years ago for their main fuel requirements at Kemsley—and still do."

Here are the details of the Bowater Kemsley boiler installation

Boilers: ..... 10 water-tube
Method of firing: ..... Chain grate stokers and pulverised fuel
Boiler efficiency: ..... 80% old boilers, 88% new boilers
Maximum steam rating: .. 940,000 lbs. per hour
Maximum steam pressure: 1,500lbs.persq.inch
Maximum steam temperature: ..... 915°F.
Annual fuel consumption: .. 320,000 tons of coal (*Kemsley alone*)

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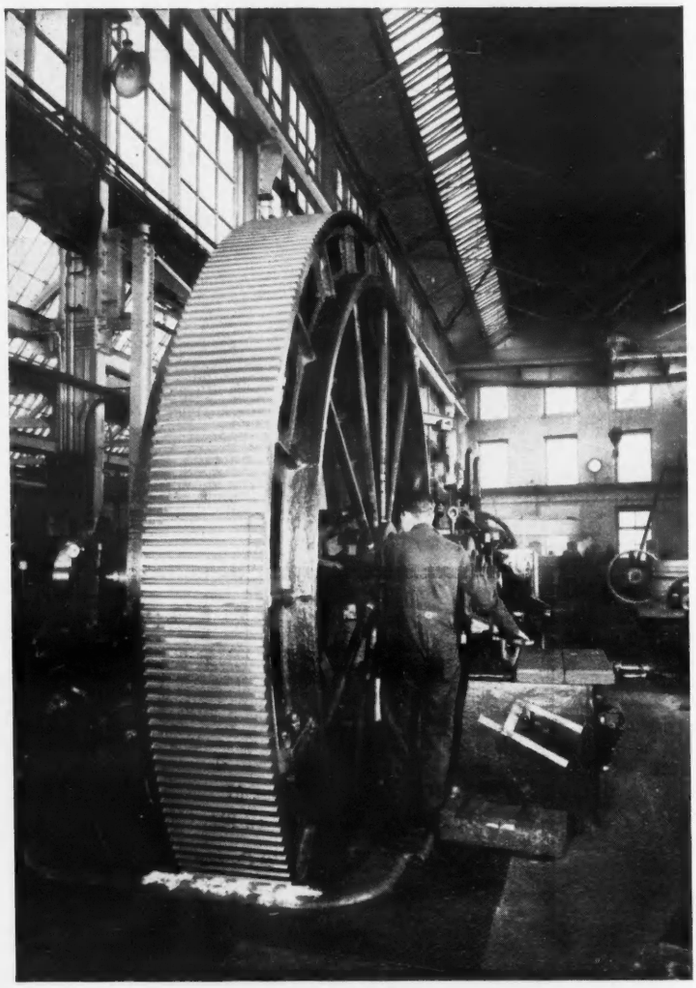

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THE ENGINEER

No. 5451 JULY 15, 1960 Vol. 210

CONFUSION IN EXTERNAL AFFAIRS

The other day we happened to read in quick succession a report of a speech by Lord Rootes extolling the commercial success of the British Exhibition in New York but emphasising the awkward fact that while British exports to the U.S.A. increased by 7.4 per cent in June and to Canada by 14.4 per cent imports from those countries increased by 95.6 per cent and 40 per cent respectively; a report of a speech by the Minister of Aviation to members of the Press Gallery of the House of Commons in which he dealt among other matters with the cancellation of work on the rocket " Blue Streak " as a weapon of war, this country's contribution to space research, and defence matters in general; a press notice from the London Chamber of Commerce about meetings members of a number of chambers of commerce in this country had had with their opposite numbers in Holland to discuss the relationship between the six nations in the European Economic Community and the seven nations which have formed the European Free Trade Area; and a note about a satisfactory increase in this country's gold reserves during June. The common factor which links all the subjects listed is that all are concerned in some way with the external affairs of this country. But how puzzling it must be for foreigners to find very much co-ordination amongst them! For in the last year of the sixth decade of the twentieth century the external affairs of this country have been thrown into a state of flux by the creation on the continent of Europe of the E.E.C.

Neither politicians, nor economists, nor industrialists, nor engineers can make up their minds whether it would profit this country better to join the E.E.C. or to stay out of it. Were the Community to be entered—supposing what is now no longer certain, that this country's adherence to it would still be welcome — it could be expected that Western Europe would be able to develop its own deterrent independent of American aid, that it would be able to afford a space research programme of the same order of magnitude as those of the U.S.A. and Russia, and that nuclear research could be pushed along more rapidly. A really coherent defence policy could no doubt be devised, perhaps within Nato, perhaps to take its place. Alternatively, this country might prefer to look outwardly towards the rest of the world, become more closely linked with the U.S.A., as by depending upon that country to supply certain weapons and to act as a market for many British goods, to build up still further connection with a Commonwealth which is growing in wealth and to join, as in E.F.T.A., with other outwardly looking European nations in a form of loose economic union. We intend, here, to make no pronouncement about what choice we think the country ought to make. But we do want to stress that the work of engineers must be influenced by any decision which is reached. There can, we think, be little doubt that co-operation between engineers in this country and engineers on the continent would be beneficial in a number of fields, notably, in the present context, in research and development in nuclear power, space research and the development of rocket missiles suited to European requirements, and other forms of armament possibly including military aircraft; and that once it was entered upon that form of co-operation might become much more complete within the E.E.C. than it could be with the U.S.A. We are also plagued by a doubt whether this country could afford to " go it alone " effectively in all those fields of engineering endeavour simultaneously. But it needs to be noted that the six E.E.C. countries seem little interested in co-operating with Britain through the mere association of this country with, for example, Euratom or the Coal and Steel Community, unless it will go the whole hog and join also the E.E.C. Possibly it would be to the advantage of engineers if Britain were to join the E.E.C.; but remembering that only about 12 per cent of this country's trade is conducted with E.E.C. countries and only about a quarter with Europe as a whole, it may well be doubted whether there might not be disadvantages for overseas traders. Perhaps the most advantageous thing that can be hoped for would be the development of E.F.T.A. into effectively a customs union by the equalisation of tariffs, thereby facilitating its eventual linkage into a customs union with the E.E.C. Such an outcome would closely approximate to Britain's original conception of a free trade area surrounding the European Economic Community and create a single market larger in population than that of the U.S.A.

SCREWY SCREWTHREADS

When, after intensive discussions between the United Kingdom, United States and Canada, "Unified" threads were standardised, it was hoped that, relatively quickly, manufacturing firms here would change over to the use of the Unified Inch range from the Whitworth and other British ranges. It was hoped that the unified thread would become the International (ISO) thread profile to bring a worldwide standard of only two sets of threads, one for the inch series and one for metric. But these hopes have not been wholly realised. That situation has arisen because it is the customer who rules the roost for many products and there has emerged no unanimity of preference amongst powerful customers. Motor-car manufacturers have standardised upon unified threads and they expect their suppliers to comply. So have large concerns such as the oil companies, Imperial Chemical Industries, Ltd., Distillers, Ltd., and others which have to obtain plant and equipment from a variety of sources and service and maintain that plant and equipment all over the world. But a number of important customers at home, and some abroad too, still have no clearly defined policy on unified threads. These include the National Coal Board, British Railways, and the Central Electricity Generating Board. The position is further complicated by the published policy of BEAMA, which seeks to wait and see which series (inch or metric) is most

significant to the electrical industry. If this attitude could be explained by an innate conservatism, combined with a too strong appreciation of the complications in maintenance likely to ensue if, for a time, more than one variety of thread was accepted and a lack of sympathy with manufacturers' difficulties, manufacturers might be tempted eventually to adopt a strong take-it-or-leave-it attitude. But, for a special reason, many manufacturers have a good deal of sympathy with these customers. For, though it is widely admitted that there is little to choose between Whitworth and the corresponding unified thread, it is also becoming widely appreciated that the old British Standard fine thread is decisively preferable in certain respects to its nearest unified counterpart.

The disadvantage to a manufacturing firm of having to supply plant to different customers with different threads is quite serious. For it is obviously a costly and bothersome matter to maintain taps, dies and measuring and testing equipment for more than one range of standard threads, not to speak of holding stocks of bolts, nuts and screws of all the varieties. Sometimes the disadvantage can go a good deal deeper. Since elements of engineering design all hang together, a relatively small change such as the substitution of one thread for another may, in fact, necessitate the making of a number of other minor changes amounting in sum to something approaching a redesign. Certain limits and fits may be involved. Almost invariably they are when a change has to be made from British to metric units. But the same situation can rule when the lesser change from present British threads to unified is made. Thus to accord with customers' preferences firms may find themselves driven to producing in effect three or more sets of drawings for otherwise standard equipment finding a ready sale in home and export markets. Until the advent of the unified thread British manufacturers had to contend only with two standard threads, British and metric; and all customers at home accepted the British threads, as did most customers abroad. Now they have to contend with three, two of which relate to the home market, whilst some customers abroad have also developed their own preferences.

What ought to be done about this situation? It is hard to say. For the real harm being done could easily be exaggerated. It appears to us probable that comparatively few firms are seriously affected, though some of them are likely to be large and important. The obvious, but not easy thing for those firms to do is to meet together and to agree to make a joint approach to their more important customers, particularly the nationalised industries, in the hope of convincing them of the need to change their policies. Thereby manufacturers might make themselves free to standardise wholly on unified threads which are acceptable all over the world.

DISPLAYING FARM MACHINERY

Last week there was exhibited at Cambridge what has been described as "the largest concentration of farm machinery to be seen almost anywhere in the world." It constituted the major part of the Royal Show, an event which has been staged annually, by the Royal Agricultural Society of England, since 1839. The show portrays just about every aspect of British agricultural practice, which means that in this "power farming" age machinery predominates. The site occupied last week covers 160 acres and about two-thirds of it was taken up with the tractors, implements and other equipment which are so essential a part of modern farming practice. Thus, in many ways, the Royal Show can be looked upon as an engineering exhibition, though such an assessment of it in no way belittles the importance of the contributions made by the livestock exhibitors, seed and fertiliser specialists and others without whose aid the show would not be complete. But we have no doubt that the Royal Agricultural Society appreciates that the support of the machinery exhibitors keeps the show going! The Royal Agricultural Society, however, which is among the oldest of this country's learned societies, is confronted with many problems about its annual show or "country meeting" as it was originally called. Like the summer meetings of most other learned societies, the Royal Show is a social occasion. But, unlike most other summer meetings, this one is open to the public. Thinking in particular of the machinery section of the show, there is thus afforded an excellent opportunity for manufacturers and users to meet and hear each other's opinions of the machines displayed. Such exchanges are by no means valueless! Yet the fact remains that the agricultural show business is not what it was in the peak years immediately after the war and the council of the Royal Agricultural Society has for some time been considering carefully the future prospects and possibilities of its annual show. The conclusion so far reached is that this event will more effectively fulfil its purpose if a permanent site is secured and it is hoped that such a site may be available somewhere in the Midlands by 1963. Whether or not a permanent abode will increase the usefulness of this important annual event is open to conjecture until some experience of it is gained. After a tour last week of the machinery section and of the area set aside for special demonstrations, the feeling is still with us that the British agricultural machinery industry might profitably think again about staging an occasional exhibition of its own. It is something that is done quite effectively on the Continent.

NOISE IS A NUISANCE

Noise is a nuisance. Particularly is it a nuisance to engineers. For many engineering products are creators of noise; yet somehow or other the amount or intensity of the noise produced must be kept within tolerable bounds. To some extent this necessity sets limits to what engineers can do. Aircraft operators, for example, are not well pleased when, to counter complaints of excessive noise from people living close to an airport, aircraft have to take off not fully loaded. There is — naturally — a come-back against engine designers. Moreover noise can be more than just a nuisance. It can be actively damaging physically. That is a point which has been appreciated for many years. The men who worked in old style boiler shops, where much hammering of rivets and plates went on and in which the noise level was very high, all tended to become deaf as the years went by; and some of them tended to become irascible too. It has also become more widely appreciated these many years past that brain work and office work generally cannot be well conducted under noisy conditions; with the consequence that modern office buildings are designed to suppress unwanted sounds. In the works, however, there is still a tendency to accept that certain operations are noisy and to claim that people who work there must just put up with the conditions. It is an attitude which is becoming less and less easy to justify. One may, indeed, still feel doubt about the validity of such evidence as does exist to prove that the efficiency of people using handicraft skills is affected by noise; but there is the hard fact that under conditions of full employment it is difficult to get people to work under objectionable conditions.

Furthermore there is now a Noise Abatement Bill before Parliament which may strengthen the powers of local authorities to take action against firms permitting noisy operations to annoy neighbours. A welcome is therefore likely to be given by many in industry to a D.S.I.R. publication which lies before us as we write. It is a booklet entitled *Noise in Factories** and after giving some particulars of sound and its effects on human beings it goes on to study methods of reducing noise levels and how they should be applied. We have no intention of reviewing this booklet in detail. But certain remarks contained in it caught our attention. For example, "It is worth bearing in mind that excessive noise from a tool, for its type and size, generally indicates low mechanical efficiency." The reference there is to machine tools; one can think of other kinds of machinery to which the sentence could only doubtfully be applied. "Unless precautions are taken to isolate its housing, an enclosed machine may be noiser, because of the large surface area, than if it were not enclosed." How many well-meaning people, we wonder, have fallen into that trap? Repeatedly the point is made that one needs to understand clearly what one is attempting to do. Amateurish attempts to reduce noise levels by what appear at first sight to be obvious methods may prove quite ineffective in practice. In a reference to the use of felt, cork, and glass wool the remark is made "In many cases a large area of material has been used with negligible effect because the mounting has been too stiff." And again, "Coil springs are very useful in giving large deflections for isolating low frequencies, but high frequencies may be transmitted along the coils unless there is another resilient material in series with the spring." Once more, "Frequently an otherwise satisfactory vibration-isolating installation is made useless by rigid pipe and conduit connections, which short-circuit the isolators." The booklet is not only concerned with the machines and equipment in a factory but with the design of the building, too. We recommend all people interested in reducing the noise levels in their factories to get a copy. For if it does nothing else it will, we think, convince them that, if money is to be well spent on attempts to reduce noise, then the advice of people who really understand the subject should be sought.

A CENTURY-AND-A-HALF OF CANS

It is just on 150 years since the first British patent (No. 3372) covering the canning of food was granted on August 25, 1810, to Peter Durand "of Hoxton Square, Middlesex, Merchant." It relates to "Preserving Animal Food, Vegetable Food and other Perishable Articles a long Time from perishing or becoming useless." The subject matter of the patent applied for by Durand was communicated "by a foreigner residing abroad". This foreigner was, it seems certain, Nicolas Appert, of Paris, who proposed the preservation of food by the process which we now call "canning." Some years earlier Appert did not, apparently, secure a French patent though it is recorded that his services in assisting to feed the armies of Napoleon were recognised by the award to him of Fr. 12,000. In the British patent he proposes to "inclose the said food or articles in bottles or other vessels of glass, pottery, tins or other metals or fit materials; and I do close the aperture of such containing vessels so as compleately to cutt-off and exclude all communication with the external air." He further describes methods of closing, cooking in boiling water and subsequently sealing the aperture, which is to be left open "until the effect of the heat shall have taken place, at which period I close the same."

While Appert is regarded as having been the first to propose the preservation of food by canning it in air-tight receptacles, much work remained to be done before the process could be deemed a commercial success. This development was carried out by Bryan Donkin, who, in association with John Hall and John Gamble, had acquired (for the sum of £1000) Durand's patent. A company was formed for carrying out the requisite technical and investigational work and thereafter introducing the process, the progress made being such that by 1813 the proprietors felt justified in submitting samples of tinned food to the Prince Regent (afterwards King George IV) at Kensington Palace. The fact of the Prince having tasted and approved the product assisted in removing prejudice against the process, so that the food canning and bottling industry made rapid headway. It is on record that when two of the original tins were opened in London after being stored for upwards of a century, the contents (roast veal in one can and carrots in the other) were found to be in excellent condition. The evolution of refinements in can making, designed to improve the process and expand the rate of production, can be followed from the specifications of successive patents, notably those detailing the steps taken in arriving at automatic methods of converting a sheet of tinplate into cans, a result not reached until the end of the nineteenth century when the lock-and-lap side seam was introduced in Germany. The later development of the "sanitary" can and of high output can-body making machines has had those revolutionary effects on the preservation and distribution of foods which are manifest to any person visiting a modern self-service store; effects never dreamed of by the pioneers who took the first steps a century and a half ago.

*H.M. Stationery Office, Price 3s. 6d.

The Engineer—100 Years Ago (JULY 13, 1860)

"The Royal Agricultural Society"

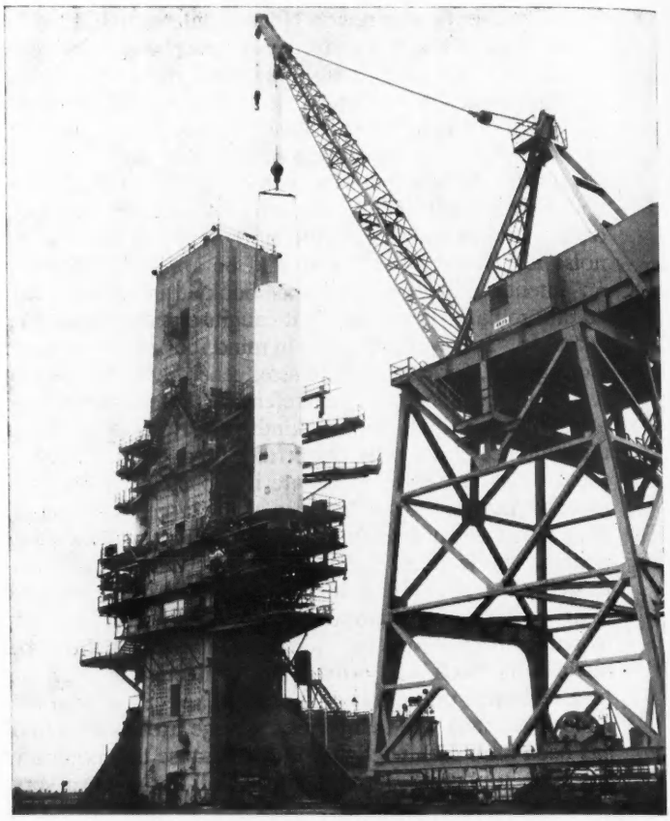
"It is alleged that some of the manufacturers who have assumed an attitude of opposition to the Society's late proceedings are altogether averse to competitive trials, and desire to see them abolished. With this it is impossible for us to agree. The abolition of trials might answer a temporary end, and would undoubtedly throw the trade, for a period more or less long, chiefly into the hands of those great firms which enjoy an established reputation. But this is an object which none but the firms themselves can possibly desire, seeing that its attainment would inevitably result in making the merit of agricultural manufacturers all but stationary. Nor is this an object which the large firms can contend for with any grace or delicacy, seeing that it is by virtue of that very competitive system which they are now said to be hostile to, that their reputations were made. But no *argumentum ad hominem* is necessary in the matter; the *argumentum ad rem* will amply suffice. We believe official and competitive trials of implements, properly conducted, are absolutely essential to the progress of the art of implement-making, and therefore to the progress of agriculture itself. We do not mean to say that the Royal Agricultural Society's trials are absolutely essential; but some such trials are, and we neither know nor can conceive of any institution possessing better opportunities than this for conducting them. The necessity for such trials arises from the fact that there are no other means by which the farmer can be honestly and intelligently guided in the selection of implements . . . Only by combining the knowledge of the farmer with that of the engineer can just decisions respecting the merits of implements be attained."

Rockets and Space Flight up to 1960

By JOHN E. ALLEN*

No. I

Recent rocket research and development is reviewed mainly in two categories: first, the advances in rocket motor technique, engineering and production; and, secondly, the characteristics and uses of rockets in missiles, space exploration vehicles and miscellaneous applications. Some attention is also paid to the important engineering developments in ground handling and launching gear of rockets and space vehicles. As there is now a very wide range of possible electrical propulsion systems under consideration for space flight, an attempt has been made to classify these in relation to their principles of operation, with indications of the present state of the art, where this can be judged from such details as have been officially released.



IT is interesting to compare the status of world rocket engineering in 1960 with that of the beginning of the 1950s.[1] Large liquid rockets, based on "V2" technique, were then being developed as boosters for the "Navaho" missile, and work was starting on the 1500 mile surface-to-surface ballistic missiles (I.R.B.M.). There was a variety of constant-thrust solid rockets for boosts and sustainers of air-to-air, ground-to-air and air-to-ground missiles, all rather small. Liquid rockets powered supersonic manned research aeroplanes such as the Douglas D.558 and the Bell X-1 and provided take-off boost for bomber aeroplanes. The Martin "Viking" was in use as an upper atmosphere probe, and the Martin "Matador" (a solid-boosted guided winged bomb) was being developed. Convair was doing studies and pilot experiments for a 5000 mile ballistic missile, but long-range delivery of the high power but heavy nuclear warheads was to be entrusted to winged guided air-breathing missiles, such as "Snark" and "Navaho."

Meanwhile, work must have started in Russia on the lightweight hydrogen warhead, and the foundations of their large liquid rocket ballistic missile programmes must have been laid. Significantly, the Interplanetary Commission of the U.S.S.R. Academy of Sciences was formed at about this time. Rocketry was, in fact, feeling its way into the missile arsenal as a propulsion system of great potentiality, and already there were signs of the tremendous performance advances it could bring about. Theoretical estimates of earth satellite launching vehicles and lunar probes were advanced with more certainty than in the previous decade.

By 1959 rocket engineering had grown out of all belief—even exceeding the expectations of its most optimistic protagonists of 1950. During the last year, the large liquid-propellant "Atlas" I.C.B.M. became operational—demonstrating a terminal accuracy of 2 miles in 6000 and a reliability of eleven successful shots out of twelve. Many "Atlas" squadrons were being equipped and new launching sites, for example, at Vandenberg in California, were opened. The 1500 mile "Thor" I.R.B.M., already well proven before 1959, began to be issued to European countries as part of the N.A.T.O. agreements. The second-generation liquid rocket I.C.B.M. "Titan" had reached the tiresome stages of its firing programme, and industrial effort on the large solid I.C.B.M. "Minuteman" (70,000 lb thrust) was beginning to grow. Significant advances were also made in the much smaller mobile ballistic Sky Bolt missiles—"Polaris" for submarines—for aeroplanes—each using sophisticated multi-stage solid rockets. The conversion of large military ballistic rockets for space vehicle boosters has continued, and plans were published for more advanced versions of "Thor" and "Atlas," but difficulties in the space programme arose from a shortage of spare ex-military boosters.

It is noteworthy that the true space propulsion systems are beginning to take shape. Engineering programmes have been laid down by N.A.S.A. for a family of eight liquid rockets for space vehicles; R. and D. programmes are in hand for improving techniques in liquid and solid rockets and their accessories; and powerful support is now being given to advanced space propulsion systems of nuclear and electric types. The large momentum in rocket development built up during the 1950s has led to a healthy rocket industry in the U.S.A., with such giants as Aerojet, Rocketdyne, Thiokol and the Grand Central Rocket Company.

Flight speeds of about 5000ft per second in 1950 compare with 40,000ft per second in 1960. This eightfold increase has come about from associated developments in propulsion, guidance and vehicle design under the impetus of space exploration and ballistic missiles.

THE PRESENT STATE OF WORLD ROCKETRY

U.S.S.R.

The Soviet Union's space flight programme has continued the pace set with the first "Sputnik," i.e. emphasis is on pioneering scientific flights, fulfilment of predictions with infallible accuracy, virtually no disclosures of vehicle design, although there has been some increase in publishing scientific results of basic engineering research and of space flights. Rather general statements have been made during the year on possible future objectives such as Mars and Venus flights, soft lunar landings of instruments and preparation for manned spaceflight. Progress in long range military rockets lies behind a series of announcements of greater range, high accuracy tests, large boosters and quantity production arrangements. Other statements have been made of increase in surface-to-air defences, presumably with rocket weapons. No disclosures of new military rocket hardware have been made.

U.S.A.

In America, the N.A.S.A. continued to expand in many ways during 1959, including the taking over of the Army Ballistic Missile Agency programme and the setting-up of new research centres. Main research areas are propulsion, aerodynamics, structures and materials, and the agency co-ordinates the work of specialist sub-contractor groups engaged on the development and manufacture of component systems and vehicles. The N.A.S.A. put forward programmes during 1959 for many[2] years ahead, covering both space research and practical applications of space vehicles. The 1959 budget for N.A.S.A. was 523 million dollars,[3] with emphasis on the large clustered "Saturn" booster and the "Mercury" man-in-space project.

* Member, American Rocket Society, Member of Council, British Interplanetary Society

The American industrial expansion for spaceflight continues. Examples during 1959 were the formation of an Astronautics Division by All-American Engineering of Wilmington, Delaware ; Massachusetts Institute of Technology's new Department of Aeronautics and Astronautics, formerly of Aeronautics only : and changes in the organisation of Lockheed, Chrysler and Martin.

United Kingdom

The year 1959 saw the first formulation of a U.K. space programme. The British National Committee for Space Research was established by the Royal Society as the body primarily concerned with scientific problems and with supervision of the programme ; financial responsibility lies with the D.S.I.R. Sir Edward Bullard is Chairman of a Steering Group on Space Research to advise the Government on the space programme. The U.K. and the U.S.A. have signed an agreement to co-operate in satellite research, permitting the first British satellite to be launched by an American "Scout" solid rocket in the U.S.A., probably in 1961 ; that design and development of equipment for the satellite would commence within six months ; and that up to twelve space research experiments were planned for a four-year programme which would cost between £100,000 and £200,000 per annum. These experiments would be managed by groups in British Universities.[4]

The programme covers research into the properties of the ionosphere, radio astronomy, measurement of ultra-violet radiation from the sun, infra-red radiation, micrometeorites, and the earth's magnetic and gravitational fields. Probable details of the first satellite were given as : 20in maximum diameter, payload 150 lb, orbit height about 300 miles.

The annual report of the Advisory Council on Scientific Policy, published on December 8, warned that it would be folly for the United Kingdom to engage in spaceflight on a purely national basis, in view of the great cost in money and manpower. "This council has repeatedly emphasised the importance of adequate expenditure on research and development in fields of endeavour which are vitally important for the welfare of our people, and for the strengthening of our economic position as well as for the improvement of living standards in the less well-developed countries, particularly in the Commonwealth and in the colonial territories. To leave these needs unsatisfied in order to shoulder the crippling cost of a large programme of space exploration on a purely national basis would be, in the council's view, the grossest folly."

Nevertheless, the Council considered that British scientists could, and should, contribute to space research, but as part of a co-operative international programme. The U.K./U.S.A. agreement on satellites was welcomed, and the report declared that the winning of scientific prestige does not depend on the size or spectacular nature of the project. Lunar, planetary, or other probes were considered too costly. The £100,000 to £200,000 expenditure on the British satellite programme was considered to be " not out of line " with other researches of comparable importance.

It should be emphasised that the report was an annual one and the above cautious approach may not necessarily apply in future years.

The keen interest in space projects among some sectors of British aircraft and electronic industries was shown by the Commonwealth Spaceflight Symposium, held in London at the end of August, and at the International Astronautical Congress which immediately followed. A number of space vehicle projects was suggested at the Commonwealth Symposium by members of the aircraft industry.

Commonwealth and Foreign Countries

In September last, Dr. D. F. Martyn, chairman of the Australian National Committee on Space Research, said that a specific programme for Australian space research was being put forward to the Federal Government. Optical and electronic instrumentation, rather than rocket vehicles, were the main concern of the Committee.

Early in the year it was announced that Canada had made arrangements with the U.S.A. for co-operative space research. It is intended that a 200 lb Canadian satellite will be launched into a polar orbit at 700 miles, using an American " Thor-Delta " booster. Purposes include radar studies of the ionosphere and measurements of radio noise from outer space. The satellite, spherical in shape, is to be equipped with solar batteries, and should be capable of conducting the experiments for a year. Launching is scheduled for the end of 1961.

Various N.A.T.O. countries are engaging in the co-operative production of missiles, mainly American—such as the " Hawk " surface-to-air defensive missile—and they will exchange component parts with each other to permit the construction of complete vehicles. The science and technical committee of a N.A.T.O. parliamentarians' conference, held in Washington in November, put forward a proposal for N.A.T.O. co-operation in space research.

The French programme is in many ways similar to the British.[5] The missile test centre at Colomb Bechar in the Sahara continues to be expanded, and was the site of several launchings of the " Veronique " and " Monica " upper atmosphere rockets in 1959. Sodium cloud tests were made in March and during 1960 this work is being continued and expanded in scope. Preparations are said to be in hand for a solid propellant I.R.B.M. which may be related to exploratory studies made by the National Office of Aeronautical Studies and Research for a high altitude research rocket and for the eventual launching of satellites. The French are active in optical and radio tracking of satellites, with about a score of stations and a central computing and correlating group at Meudon.

Italy contemplates expanding the Sardinia range for missile uses. The West Germans are reported to be considering the establishment of a test range. Sweden, it was announced early in the year, has built missile test facilities on the Baltic, using British equipment, and has embarked on design studies for a satellite vehicle.

Japan has announced her intention of building a test range on Niijima Island in the Izu group. The Japanese Rocket Society held a Symposium on Rockets and Astronautics in Tokyo last year, and it was later reported that Japan was considering the formulation of a five-year space programme.

China is believed to be planning satellite experiments with Russian launching vehicles.

ROCKET PROPULSION

Trends in rocket motor development relate to the following objectives :

Increase in thrust.
Reduction in system weight.
Improvement in specific impulse.
Improvement in operational readiness.
Better reliability.

The technical problem is complicated by the very large number of types of rocket that is being actively worked on. For development of a given system the objectives of research may be clear, but the vehicle designer may be faced with an embarrassing choice of alternative ways of meeting his requirements. Many of the developments are relatively new, so that the vital facts of service experience are unknown, and have to be estimated at the time important design decisions are taken.

A possible classification of types of rocket has been used in this section, as follows :

Chemical Rockets.—Defined by type of propellant, viz., solid, liquid, storable liquids, and hybrids : these are generally capable of high thrust-weight ratio and are applicable to missiles and space vehicles for launching from planetary surfaces.

Nuclear Rockets.—Nuclear power can be used in two ways. (i) By using reactor heat to eject a working fluid—such a system having the high acceleration capability of the chemical rockets. (ii) By producing electrical power from a nuclear source. The electrical power is then used with special electrical rockets, viz :

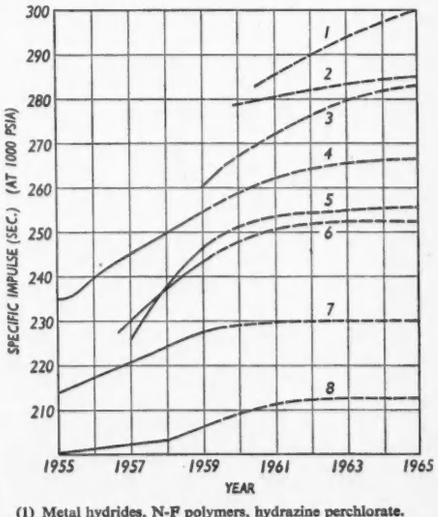
Electric Rockets.—Plasma jet, ion drive, and photon rockets : these are all low thrust, high weight space propulsion systems in the theoretical and experimental stages.

Solid Chemical Rockets

There is now a great drive[6] for improving solid chemical rockets, and recent developments have widened the scope of this technique considerably. A good indication of this is given by the 15,000,000 dollars[7] expenditure for solid rocket research allocated by the U.S. Advanced Research Projects Agency, distributed amongst nearly sixty authorities in industry, universities and government centres. 1959 showed tangible results in the following areas :

Continued increase in size of solid rockets (up to 300,000 lb thrust).
Increases in specific impulse above 250 lb second per pound with 300 as a research goal.
Introduction of new chemical compounds.[8]
Solutions to thrust control and steering.
Significant improvement in quality control and reliability.
New fabrication techniques.
Cheaper propellants.

Fig. 1 illustrates the performance trends



(1) Metal hydrides, N-F polymers, hydrazine perchlorate.
(2) Metal hydrides, viton, hydrazine perchlorate.
(3) Metal hydrides, viton, ammonium perchlorate.
(4) Nitrasol (with metal hydrides for I_s above 255).
(5) Cban (with metal hydrides for I_s above 245).
(6) Polyurethane (with metal hydrides for I_s above 245).
(7) Polysulphide.
(8) Ammonium nitrate.

Fig. 1—Solid propellant growth potential

Fig. 2—Solid propellant vernier motor supplying 1000 lb to 10,000 lb-sec of total impulse for "Polaris"

of several chemical compounds for solid rockets. An interesting recent high performance combination is Nitrasol, applied to a family of solid propellants developed at

Fig. 3—Close-up of mixer blades in 350 gallon solid propellant mixer of the Grand Central Rocket Company

the Naval Ordnance Test Station and Grand Central Rocket Company. The propellant binder is made of nitrocellulose and one or more high-energy plasticizers. The propellant contains ammonium perchlorate and aluminium to provide a delivered specific impulse above 250 lb second per pound. Another important class of propellant is that of the polyurethanes—a polymer formed from a polyester and a urethane (a diisocyanate). These have elastic properties akin to gums and rubber and are excellent for the two common fabrication methods of casting or extruding.[9] They contain carbon, hydrogen, oxygen and nitrogen and offer higher performance than the older polysulphide group not only because of higher heat content but particularly because of their lower molecular weight exhaust products.[10] Efforts have been successful in increasing the propulsive contribution of some binders and considerable enhancement is afforded by the addition of powdered metals such as aluminium, magnesium and zirconium.[11] As specific impulse increases with these additives so does the danger of premature reactions, but this can be minimised by surface treating the metal particles.

Increases in propellant specific impulse have been backed up by techniques of reducing case and nozzle weight. High tensile steels (300,000 lb per square inch) are now available as thin multi-ply helical strips wrapped with plastic bonding. Another technique uses fibreglass bonded cases.[12] Lightweight nozzles employ heat-resisting phenolic, phenolic-silicone plastics[13] and "Refrasil" silica glass fibres. It is claimed that ablating plastic nozzles offer an acceptable solution for coping with increased exhaust temperatures. Developments continue, however, with nozzles of such metals as tantalum and tantalum-tungsten alloys, carbide coatings, cermets and reinforced ceramics.

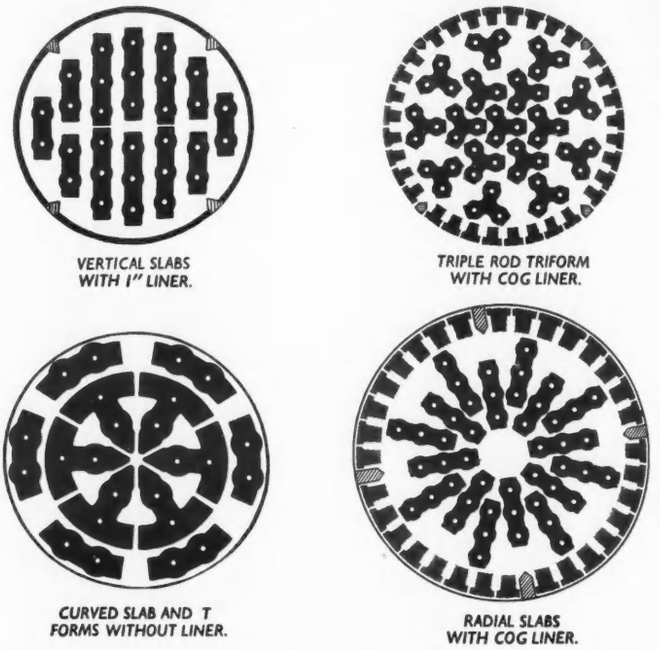

VERTICAL SLABS WITH I" LINER.
TRIPLE ROD TRIFORM WITH COG LINER.
CURVED SLAB AND T FORMS WITHOUT LINER.
RADIAL SLABS WITH COG LINER.

Fig. 5—"Astrodyne" modular charge configuration

The great advances made in thrust control, both for magnitude and direction, have advanced the application of the solid rocket for accurate long range ballistic missiles. Thrust can be cut off in a predictable manner by blowing out the head end or quenching by liquid injection. Two-level thrusts can now be provided in solid rockets by varying the charge design throughout its volume.[14] The exclusively solid rocket "Polaris" submarine missile uses a swivelling nozzle of molybdenum for vector control and a vernier cut-off rocket (Fig. 2). "Chuffing," or delayed burning of propellant after shutdown, is still somewhat of a problem, having, of course, serious consequences on ballistic missile velocity accuracy.

Another interesting advance announced by Astrodyne† in 1959 is the use of modular charges to permit considerable versatility in the thrust-time and total impulse characteristics of a given size of motor (Fig. 5). Thrust depends on the burning surface area and chamber pressure. This versatility is of particular advantage for experimental test sleds for which 1,000,000 lb second impulse boosters are available. The application of this technique could assist flight experimental vehicles also.

Considerable care is needed in the several stages of preparation of solid rockets, mixing, casting and curing.[15] Progress has been made in more automatic operations (Fig. 3), safer handling of larger mixes (Fig. 4) and arrangements to pour large rockets, cold, in underground launching sites. Quality control and inspection systems play a vital role in manufacture and several companies[16] published their techniques[17] during 1959. Thiokol claims[18] that more than 3000 of its solid motors[19] have fired without malfunction and that its policy is to fire 3·5 per cent of its production to verify quality control results. Radiographical

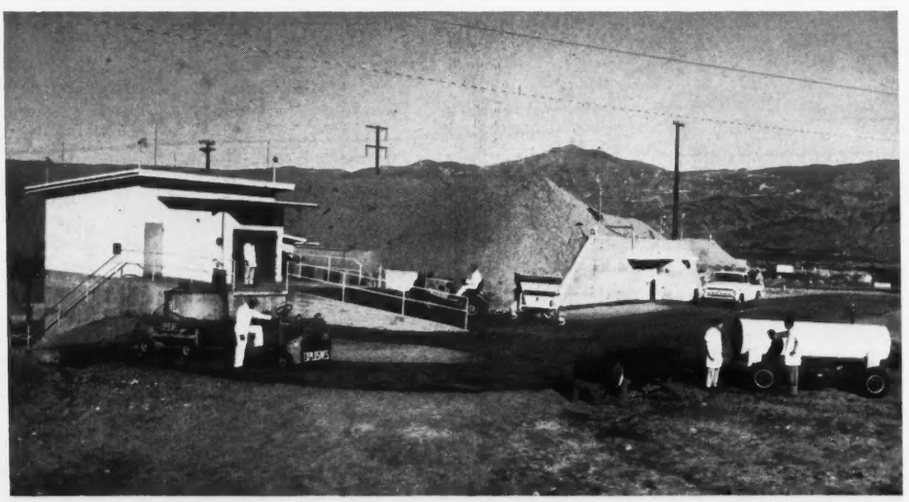


Fig. 4—Above-ground view of the largest solid propellant mixer in America, which has a batch capacity of 350 gallons

† Now part of North American Aviation, Inc.

inspections and isotope tracer techniques are proving invaluable. The operational readiness and reliability of starting are two key advantages of this type of rocket.

Liquid Chemical Rockets

Technical progress in liquid rockets has been no less vigorous than that of the solids. Highlights in recent advances are :

Very large thrust rockets for space vehicles —$1{\cdot}5\times10^6$ lb—Rocketdyne.

Increase of specific impulse—cryogenic propellants, e.g. liquid fluorine, liquid hydrogen.

Improvement in startability—pumps, pyrophorics.

Increase of reliability—system simplification.

Storable liquid systems.

As solid rockets have entered the long-range ballistic missile field the liquid engines are at present taking the major share of space vehicle propulsion. This trend is underlined by the family of eight engines now on contract for the N.A.S.A. space programme :

6000 lb thrust storable liquid fuel motor with pressurised tanks by the Jet Propulsion Laboratory (1960).

15,000 lb thrust liquid hydrogen and oxygen engine by Pratt and Whitney (1959).

20,000 lb storable engine with pumped propellant system for 1963.

80,000 lb thrust liquid hydrogen and oxygen engine for 1963.

1,500,000 lb thrust kerosene liquid oxygen by Rocketdyne for 1963.

34,000 lb thrust engine based on " Vanguard " first stage—General Electric.

190,000 lb thrust kerosene liquid oxygen engine developed from Rocketdyne I.R.B.M. rockets to be used in clusters for " Saturn " space booster.

Large Thrust Rockets

The largest thrust single-chamber engine now in use is the 165,000 lb Rocketdyne using liquid oxygen and RP-1 kerosene propellants. This basic design is probably capable of giving up to about 200,000 lb with development. This thrust level is inadequate for large space missions envisaged in the next decade. Such engines can be clustered, but there has[20] been a drive to produce engines in the 1,000,000 lb thrust class. The largest thrust liquid rocket design published to date is the " Aerojet 1," a 2,000,000 lb thrust engine, shown in mock-up form in Fig. 6. The increase of scale from previous engines is indicated by its nozzle diameter of nearly 10ft and overall length of nearly 25ft. The pumping rate of propellant is of the order of 5000 lb per second. Considerable development will be needed to introduce engines of this size, and interesting scaling problems in heat transfer, combustion, metallurgy, corrosion and strength will have to be solved. Combustion instability will be affected by the lower natural frequency of the gas and the higher energy levels. This rocket is reported to be intended for operations in 1965.

Rocketdyne fired on the ground a 400,000 lb single-chamber[21] research and development liquid rocket motor (Type E-1) in 1959. This is providing invaluable data on turbo machinery, combustion and systems operations for the large liquid engines. This engine, not specifically allocated for any vehicle, is an outcome of the theoretical and practical studies made for the N.A.S.A. research contract for a 1,000,000 lb to 1,500,000 lb engine.

The Advanced Research Projects Agency has sponsored work at Rocketdyne to cluster

Fig. 6—Full-scale mock-up of an engine capable of generating between 1,000,000 lb and 2,000,000 lb of thrust (Aerojet-General)

eight " Jupiter " engines in a 1,500,000 lb booster for the N.A.S.A. " Saturn " space vehicle. This unit will appear two to three years earlier than the large single-chamber engine of the same thrust (Type F-1).

Better Performance with New Propellants

The quest for " exotic " liquid propellants was brought to a decisive stage in 1959 with continued firings of fluorine motors and, particularly, the announcement of the Pratt and Whitney liquid hydrogen engine (Fig. 7). A typical review[22] of a wide range of liquid propellants was given to Agard by D. L. Armstrong of Aerojet General. This gives physical and chemical data and compares many fluids on the basis of requirements of different applications. Perchloryl fluoride is claimed to be the only new liquid compound potentially suitable for rocket propulsion that has emerged in the last twenty years.

Fluorine engine progress has been slower than might have been judged even four years ago, considering that N.A.C.A. demonstrated a test engine in 1949. Rocket companies engaged on fluorine motor research are Bell, Rocketdyne and J.P.L., with active programmes such as the 1,070,000 dollars for Bell to assess feasibility of the liquid hydrogen-fluorine rocket. N.A.S.A. Lewis Laboratory has a test facility for 26,000 lb thrust fluorine engines built at a cost of 2,500,000 dollars. The results of work performed during the 1950s indicate that fluorine engines are feasible,[23] with specific impulse better than 300. Compared with liquid hydrogen they give far better volume specific impulse (see Fig. 10). The corrosive nature of liquid fluorine has set severe engineering tasks in gaskets, seals, pumps and lubricants. Knowledge gained in the atomic energy programme with gaseous uranium hexafluoride has helped, but the difficulties appear in extreme forms with the liquid fluorine. Present solutions are soft aluminium, fluorocarbons and silicon gaskets, and engine system redesign to avoid gaskets. Monel metal and stainless steel seem most likely metals for other parts of the engine. Other aspects being tackled are transportation, raw material supplies and cost. Single shipments of 5000 lb of liquid fluorine can now be taken by road ; ample supplies of the ore fluorspar are available in the Western world—present costs of about 3 dollars per pound might reduce to 1 dollar per pound for operational quantities. Its high toxicity puts fluorine at a disadvantage compared with liquid hydrogen and oxygen and has no doubt hindered the introduction of fluorine rockets for missiles. However, this may not be such a serious objection for spaceflight applications where the performance benefits can be very high. N.A.S.A. has stated that a fluorine rocket system could orbit a 20,000 lb manned satellite for half the booster weight of conventional (lox-kerosene) boosters. On a round trip to the moon the fluorine/hydrogen rocket could increase payload take-off weight ratio by a factor of 8.

Attractive though this appears it must be set against the relative cost of about 1 dollar per pound for fluorine (at best) compared with 10 cents per pound for liquid oxygen.

In November, Rocketdyne reported the development of a liquid hydrogen-liquid fluorine engine called " Nomad." Another version is capable of using hydrazine-fluorine.

Perhaps the most significant event in rocket engineering in 1959 was the Pratt and Whitney Aircraft XLR 115 liquid hydrogen-lox engine. This engine has a thrust of 15,000 lb and has run for several minutes on the test stand under conditions representative of space environment. The introduction of liquid hydrogen, giving over 30 per cent better performance than lox-kerosene, promises to give a very great advance towards the much-needed better fuels for spaceflight. Behind this announcement lies a vast amount of engineering accomplishment, not only in the engine itself but also in the manufacture, storage and transport of this interesting fluid.[24, 25] As this development has been so rapid it is appropriate to discuss the properties of liquid hydrogen,

Table I—*Typical Liquid Rocket Characteristics*

Liquid	Density, lb/cu. ft	Boiling point, deg. K	Viscosity, c.p.	Combined with	Propulsion performance of propellants	
					Specific impulse, lb sec./lb	Bulk specific gravity
Bipropellants :						
Liquid oxygen (O_2)	71·1	90	0·19	Kerosene	250	1·02
Liquid ozone (O_3)	101	161	?	Liquid H_2	375	0·23
Liquid fluorine (F_2)	110	85	?	Liquid H_2*	370	0·46
Liquid hydrogen (H_2)	4·73	20·3	0·014	Lox	345	0·23
Hydrazine (N_2H_4)	62·4	386	0·90	Lox	265	1·07
				F_2*	300	1·31
High test peroxide (H_2O_2)	87	415	1·16	Kerosene	235	1·28
Ammonia (NH_3)	41·1	275	0·27	Lox	250	0·86
Typical storable	—	—	—	—	—	—
Nitrogen tetroxide (N_2O_4)	93·2	294	0·44(?)	Hydrazine*	250	1·19
Typical monopropellant	—	—	—	—	—	—
Nitromethane (CH_3NO_2)	70·5	374	0·65 (21 deg. Cent.)	—	220	1·13

* Hypergolic mixture. Theoretical values at 300 lb per square inch chamber pressure, sea level frozen compositions.

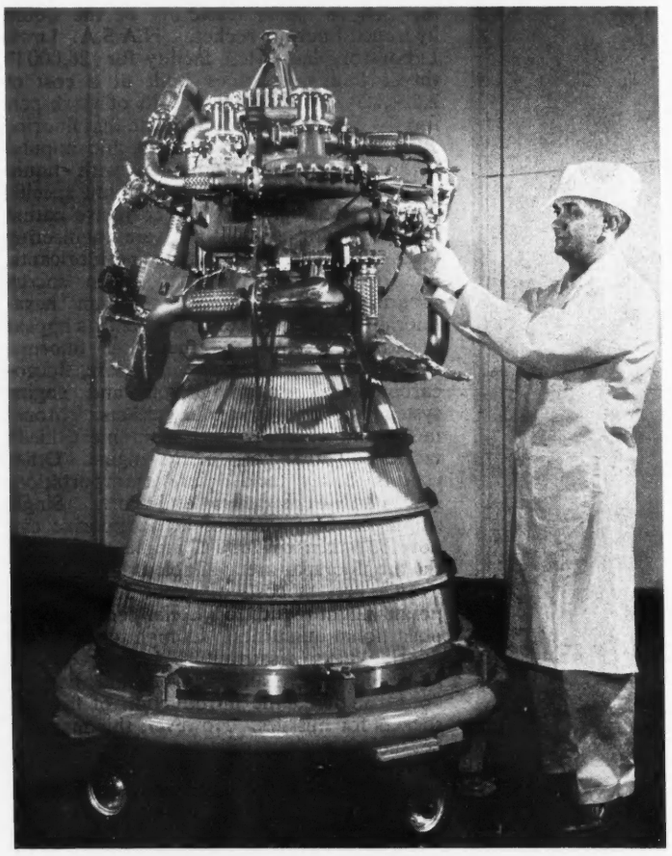


Fig. 7 (above)—The Pratt and Whitney aircraft XLR 115 has operated for several minutes at a time, achieving the rated thrust of 15,000 lb, and producing a specific impulse more than 30 per cent greater than current kerosene-fuelled rocket engines

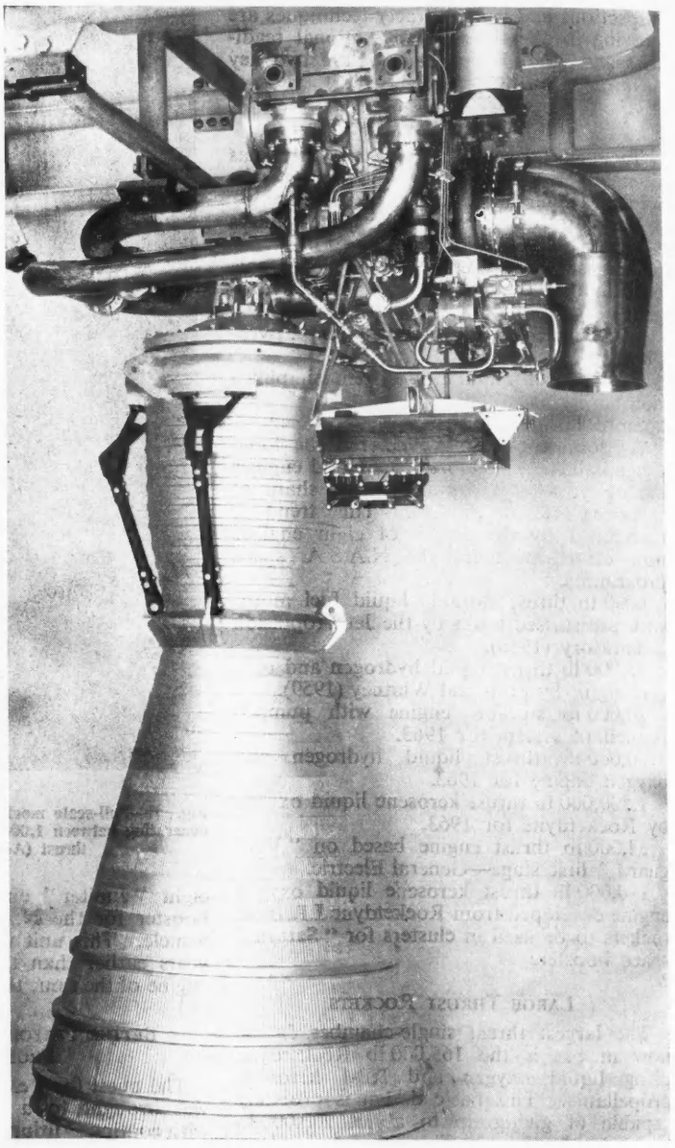


Fig. 8 (Right)—The engine built by Rolls-Royce contrasts with the present Rocketdyne design in having a conical rather than a low-loss axial-discharge nozzle

and what special engineering techniques are needed to deal with them.

Hydrogen's low density and viscosity introduce pumping, gasket and valve problems far worse than those of, e.g. liquid nitrogen. The liquid cannot be used for lubrication, and the low latent and sensible heats per unit volume complicate the removal of compression and friction heat.[26] The very low temperature imposes restrictions in suitable materials, e.g., many types of steel will crack on contact. In spite of these unusual problems, Pratt and Whitney have very effectively solved the pumping problem on the XLR-115 engine by pre-heating the hydrogen through the double-walled combustion chamber (Fig. 9). Severe metallurgical problems are introduced by the extreme temperature differences across the combustion chamber walls which also vary rapidly with time during the starting process. These engines are to be used in pairs in the " Centaur " upper stages.

Aerojet General has produced a liquid hydrogen pump capable of feeding 500,000 lb thrust engines. Development of this type of pump indicates the prospect of 10,000,000 lb thrust motors.

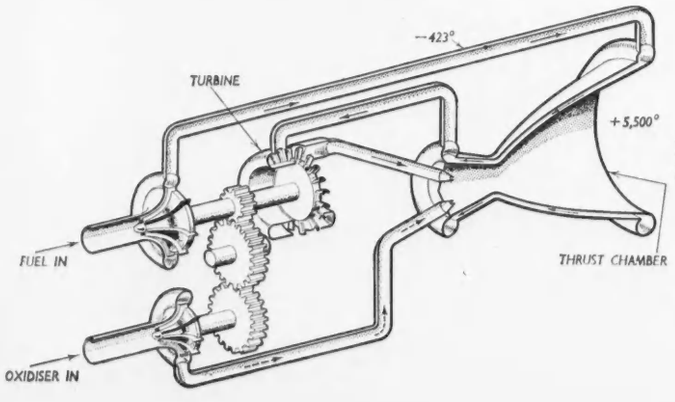


Fig. 9—The cycle of this liquid hydrogen-liquid oxygen engine is adiabatic

Manufacture, insulation and transport of liquid hydrogen is discussed later in the section on Ground Support Equipment.

Improvements to Existing Classes of Liquid Rocket

A good example of improvement by steady engineering evolution is afforded by Rocketdyne experience on its 150,000 lb lox-kerosene units originally designed for the " Navaho " booster in the late 1940s. These engines are now used in " Atlas " (types MA-2 and MA-3), " Thor " (MB-3), " Jupiter " (S3D) and " Saturn " (H-1), and have been used as the basis of the scaled-up versions E-1 and F-1 already described.

Performance gains have been achieved by increased chamber pressure, more efficient pumping by elimination of cooled nozzle skirts, and the use of exhaust gas for pump drive and higher pressure pumps.[27] Subtle adjustments of propellant mixture ratio and metal additives are proving helpful also.‡ The higher metal temperatures associated with performance improvement have been met by metallurgical advances such as Inconel-X instead of nickel for thrust chamber wall tubes, Rene 41 cobalt alloys, and

‡ In the quest for exotic propellants some important performance gains to be had from less radical changes should not be overlooked, e.g. the use of kerosene instead of alcohol gave a 4½ per cent improvement in a range of 1500 miles for an I.R.B.M., and "Hydyne" (U.D.M.H.) gave 10–15 per cent better performance than kerosene.[28]

aluminium castings with beryllium additives. Molybdenum, although an excellent high-temperature metal, catalyses some storable fluids and is not favoured. A solution to higher temperatures is afforded by aluminium and zirconium oxide plasma-sprayed linings. Weight reductions have resulted from fibre-glass-wrapped thrust chambers,[29] and smaller pumps and auxiliaries. The Mk. I Rocketdyne pump weighed 300 lb, and pumped 1300 g.p.m. for 850 h.p. ; this has led to a recent type of 50,000 h.p. for 30,000 g.p.m. Although only twice the size, its power output is greater by sixty times.

The Rolls-Royce engines for the De Havilland " Blue Streak " L.R.B.M. were developed under licence from Rocketdyne. No details of its design or performance have so far been revealed, but Fig. 8 shows a different chamber shape—conical instead of bell-mouthed.

The well-known objection to liquid engines is the large number of components whose reliability may be costly to ensure. Rocketdyne gave data[30] reduction of liquid rocket system complexity as follows :

Year	1955	1959	1960
Number of components ...	88	33	5
Number of sub-systems ...	8	3	2

Another indication of efforts to acquire large amounts of engineering experience is the report of 4000 ground-firing tests made by Rocketdyne during 1958, using 24,000,000 gallons of liquid oxygen.

Another essential operational quality is dependability of starting. A new philosophy has now been introduced whereby the slow, progressive start used in the " V-2 " is replaced by a very rapid start to full thrust (in about half a second). This may cause such problems as severe vibration in the vehicle structure during launching.

Storables and Monopropellants

There has been continued progress in small prepacked units for tactical missiles, conversion of large ballistic missiles to storables, and new developments of very high thrust storable fuel engines.

Thiokol[31] has produced the prepacked liquid " Guardian I " and " Guardian II " which replace the solid motors used in " Sparrow III " and " Bullpup." The motors are metal cylinders 4ft long by 8in diameter and they contain no pumps, shafts or valves. The cylinder contains an inner cylindrical core which seals in a solid charge propellant-pressurising medium. Inhibited red fuming nitric acid is the oxidiser, which is in the forward part of the annular volume, and fuel (an amine base) is in the rear. The " Rokide " coated combustion chamber is welded to the rear of the central cone. After filling with liquids (accurately to $\pm\frac{1}{2}$ oz), the unit is finally sealed by welding. Starting is instantaneous by an electrically initiated igniter cartridge. The body is 6066–T4 (or T6) aluminium alloy throughout, except for the copper nozzle and a small portion of 3in steel bar. Manufacturing operations have been well considered in the design and the production line is semi-automatic.

In November it was announced that the Martin " Titan " I.C.B.M. (two Aerojet engines) may eventually change from lox-kerosene to nitrogen tetroxide-hydrazine which can be stored for almost indefinite periods. Some performance improvement is also expected. These propellants are also used in the Caltech J.P.L. 6000 lb storable rocket engine[32] originally intended for the N.A.S.A. " Vega " space vehicle. These liquids are hypergolic (i.e. ignite on contact) and the design has evolved an uncomplicated feed system and integral tanks.

Thiokol have announced research directed to very large storable rockets and that a 50,000 lb thrust unit was fired in 1959.[31]

The status of future storable liquids is not unexpectedly surrounded in secrecy, but the following fluids have been mentioned as having high specific[33] impulse, together with good storage qualities :

Chlorine trifluoride, nitrogen tetroxide-lithium borohydride, aluminium borohydride-bromine pentafluoride.

Interest in storables for space flight is centred on applications near planets, where high convective and radiative heat transfer may put cryogenics at a disadvantage. An interesting, typical research conducted by N.A.S.A.[34] evaluated hydrazine-nitrogen tetroxide and hydrazine-chlorine trifluoride for performance and for injector design. Triplet injectors gave the best performance, and nitrogen tetroxide was superior to the chlorine trifluoride and also less sensitive to injector design.

Monopropellants do not feature prominently for rocket propulsion at the moment, although many agencies and companies maintain interest and continue research. The advantage of a single fuel is outweighed by lower specific impulse and/or greater explosion risk than apply to solids or bipropellant liquids. Fluids currently in the literature are[35, 36, 37, 38] hydrogen peroxide, ethylene oxide, propyl nitrate, nitromethane, diethyleneglycol dinitrate. Monopropellants are still of value as auxiliary power generators and for small JATO units.

Some Recent Research Tasks

It is a long and difficult path from the creation of a new engine specification to its operational acceptance in a new vehicle, and unexpected phenomena may only show up at an advanced flight test stage. One such example is the effect of rocket jet efflux expansion at very high altitude on the vehicle aerodynamics and between clustered engines.[39] In a typical ballistic missile up to about 50,000ft the jet is sensibly parallel, but from 100,000ft upwards the expansion is markedly increased, and at 300,000ft the flame can reverse around the nozzle lip and cause structural failure of the skirt. The airflow pattern round a ballistic body base and any number of jets is virtually impossible to predict, and there has been evidence of a considerable amount of supersonic tunnel testing with representative hot jets on a series of missiles. The U.S.A.F. Arnold Engineering Development Centre at Tullahoma has been involved in this. Clustered engine exhausts, when expanded, can trap air which then transfers unacceptable amounts of heat to the base. The recognition of the importance of interference effects between rocket exhausts and a missile structure has been turned to profitable account in a proposal for a plug nozzle.[40] A central conical " spike " is mounted beneath the missile base and a ring of combustion chambers surround it. The nozzles do not have an expansion " bell " in the conventional way, but the efflux is induced to expand by flowing past the central plug. This avoids the previously mentioned trouble of trapped dead air in exchange for a critical problem of heat transfer to the material forming the end of the " spike." Directional control of thrust can be obtained by altering the propellant supply to some of the motors. Aerodynamic control of thrust direction has, of course, been tried before, by means of air injection at specific points in an exhaust nozzle to induce gross flow separation and deflect the main jet.

Other wind tunnel studies made on rocket nozzle behaviour under representative high altitude conditions have revealed errors in heat transfer data and that convection cooling of nozzles was less than predicted. These effects are believed to explain some flight failures of plastic nozzle liners of solid rocket motors.[41]

In recent years a great deal of research has been directed to the problem of instability of combustion and propellant systems of liquid rocket engines. In the course of this work, many advanced theoretical techniques have been evolved to analyse the loop dynamics of an engine fuel system and combustion. These techniques expedite the explanation of complex instabilities and more swiftly lead to solutions. A good example of this approach was a report published by the N.A.S.A. Lewis Research Centre in November, 1959.[42] This work was done in order to develop a control system capable of starting the hypergolic combination of liquid hydrogen-fluorine and providing accurate control of mixture ratio for a wide range of thrust.

Comparison of Chemical Rocket Systems

The final choice of rocket for a given vehicle is clearly not easy, and often the availability of a proved system may decide

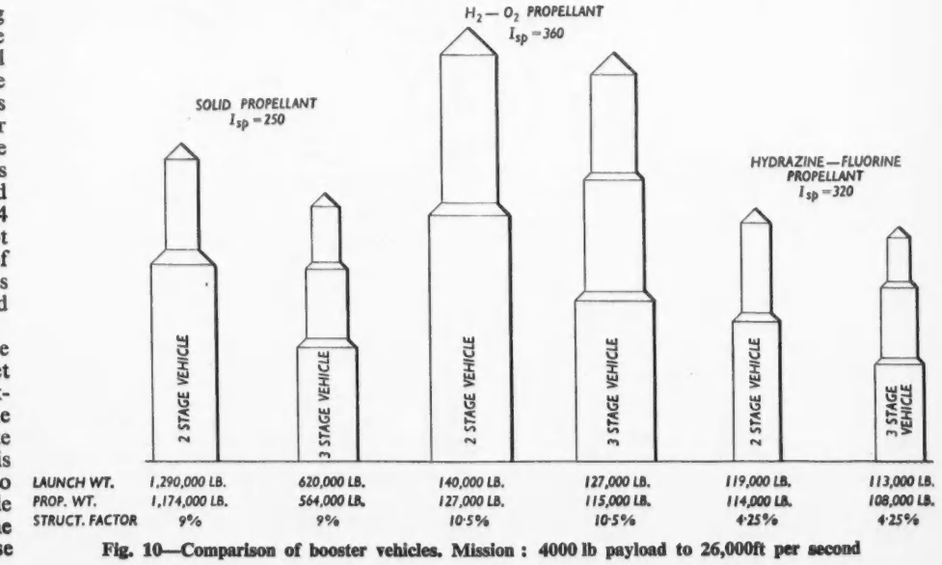

$H_2 - O_2$ PROPELLANT
$I_{sp} = 360$
SOLID PROPELLANT
$I_{sp} = 250$
HYDRAZINE—FLUORINE PROPELLANT
$I_{sp} = 320$
2 STAGE VEHICLE
3 STAGE VEHICLE
2 STAGE VEHICLE
3 STAGE VEHICLE
2 STAGE VEHICLE
3 STAGE VEHICLE
LAUNCH WT. 1,290,000 LB. 620,000 LB. 140,000 LB. 127,000 LB. 119,000 LB. 113,000 LB.
PROP. WT. 1,174,000 LB. 564,000 LB. 127,000 LB. 115,000 LB. 114,000 LB. 108,000 LB.
STRUCT. FACTOR 9% 9% 10·5% 10·5% 4·25% 4·25%

Fig. 10—Comparison of booster vehicles. Mission : 4000 lb payload to 26,000ft per second

the day. Paper comparisons may be helpful or misleading depending on how thoroughly they have accounted for significant parameters. Anyone attempting to compare liquids with solids on purely performance grounds will arouse severe controversy in many quarters. However, some important differences appear by elementary project calculations of three ground launched ballistic vehicles for satellite launching. The three types of rocket considered are a solid of specific impulse 250 lb seconds per pound, a liquid hydrogen-oxygen system of 360 lb seconds per pound and a hydrazine-fluorine rocket with S.I. of 320 lb seconds per pound. The comparison, shown in Fig. 10, brings out clearly the volume disadvantage of liquid hydrogen, bringing with it extra structure weight (allowed for), and other penalties such as larger gantries, transport and assembly cost, &c. (not allowed for). Propellant costs have been quoted in a Rand Corporation report[43] as solid 0·5 dollar per pound, liquid H_2—O_2 at 0·125 dollar per pound and hydrazine-fluorine at 1·25 dollars per pound. The propellant costs of the liquid hydrogen are very low on this basis—£6,350 and £5,750 for the two- and three-stage rockets respectively.

These estimates give a fair comparison of weights and sizes ; cost figures are somewhat misleading for an overall comparison as they depend critically on some of the assumptions, e.g. the fluorine costs quoted are those that would apply once a large quantity was in production.

The foregoing has shown the great versatility of chemical rockets for large and small missiles and space vehicles. The limit has clearly not yet been reached in size, or further development of existing systems, or in the introduction of radically new chemicals. Space does not permit an analysis of the state of the American rocket industry,[44, 45] but some indication of the scale of operations is afforded by the list of missile motors now being manufactured by Aerojet General and Thiokol.

AEROJET-GENERAL

"Titan"	Liquid propellant rocket engines
"Thor-Able"	Second stage rocket engine
"Vanguard"	Second stage rocket engine
"Regulus II"	Solid propellant booster
"Minuteman"	Solid rocket propulsion
"Bomarc"	Liquid rocket booster
"Nike-Hercules"	High explosive warhead
"Polaris"	Solid rocket propulsion
"Aerobee-Hi"	Entire vehicle
"Tartar"	Solid rocket engine
"Hawk"	Solid rocket engine
"Sparrow III"	Solid rocket sustainer
"Bullpup"	Solid rocket engine
"Genie"	Solid rocket engine

THIOKOL

"Minuteman"	"Bomarc"
"Pershing"	"Nike-Hercules"
"Bullpup"	"Falcon"
"Sergeant"	

MISCELLANEOUS CHEMICAL ROCKETS

There have been some interesting applications of small rockets for a surprising variety of tasks. Aerojet announced the first approved standby rocket power for small commercial aircraft. This "Junior J.A.T.O." (Type 15 NS-250) is about 2ft long, 6in diameter, and can be quickly inserted in the rear fairing of the wing engine nacelles. It provides 200 h.p. for fifteen seconds.

Aerojet and Thiokol showed military personnel rocket packs designed to lift troops over rivers, trees, and rocky terrain. Development of underwater rockets for submarine warfare has been undertaken at least by Aerojet-General.

There has been a continued growth of small rockets for cable-laying and the use of liquid rocket jets for quarrying and rock cutting.

Experiments have been made into the use of unmanned rocket vehicles as mail carriers, but this does not seem to be a very fruitful development. There has been news of American work directed to the delivery of combat troops into battle over hundreds of miles by ballistic missiles. The status of this project is not known, but may have been sidetracked for the more important work on "Mercury."

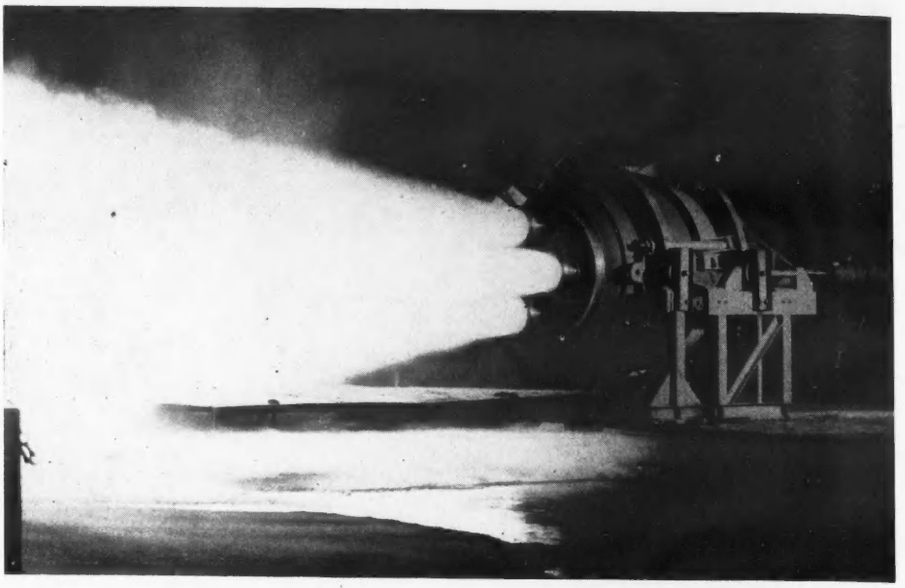


Fig. 11—An engine for the "Polaris" missile running on a thrust measuring stand

NUCLEAR ROCKETS

Here we discuss rockets using a working fluid which is heated by passing through a nuclear reactor. The principle of this class of rocket is well known, as shown schematically in Fig. 13. Theoretically, nuclear rockets offer the advantage of higher specific impulse than chemicals, in the range 750 lb–1500 lb seconds per pound, with sufficiently high thrust-weight ratio to permit departure of space vehicles from planetary surface gravitation. With presently envisaged systems they are, however, very large. Classical theoretical treatments on nuclear rockets were[46, 47] supplemented in 1959 by a growing volume of published data including engineering and experimental aspects.[48, 49, 50, 51, 52] At the Commonwealth Spaceflight Symposium, H. O. Wyatt§ presented design studies[53] for nuclear fission rockets using liquid hydrogen or ammonia, with plutonium or uranium graphite - moderated thermal reactors working at 2500 deg. Cent. Typical minimum weight of a ballistic nuclear rocket capable of reaching satellite velocity was given as 250,000 lb, with a specific impulse of 675 lb seconds per pound (hydrogen-uranium). Much better performance results from higher reactor temperature, particularly if the hydrogen can be dissociated significantly.

Hydrogen	Reactor temperature, deg. Cent.	2000	3000	4000	6000
	Typical Specific Impulse, secs.	700	900	1000	1300

The 4000 deg. Cent. envisaged in reference 46 poses tremendous materials problems, well beyond the capacity of existing engineering substances. New materials being considered for such uses include molybdenum carbide ; zirconium carbide ; tungsten carbide.

In the United States, the N.A.S.A. and the Atomic Energy Commission have an active programme (started before 1957) on nuclear rockets for spaceflight. The first ground test reactor "Kiwi-A," has already started operating in Nevada.[55] Little data has been published,[56] but this unit, which is very large, is intended for the initial exploration

§ Hawker Siddeley Nuclear Power Company.

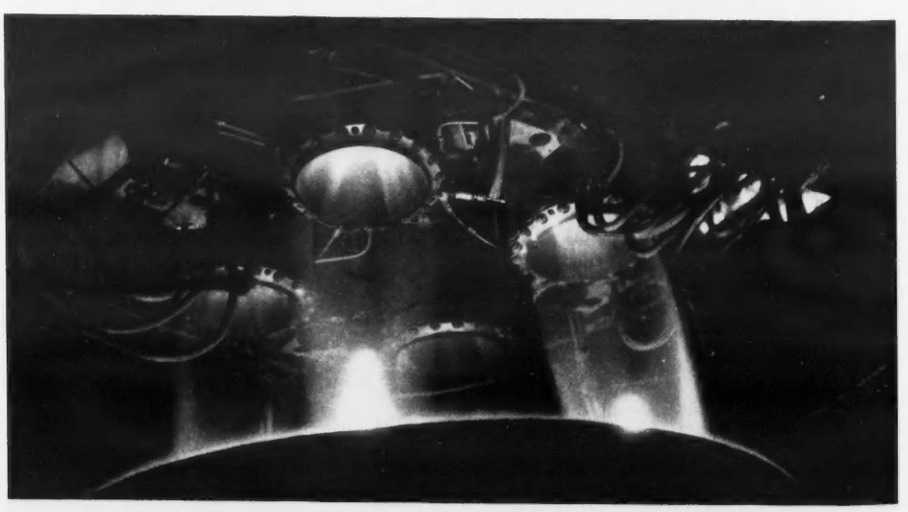


Fig. 12—The "Gamma" engine for "Black Knight" under test

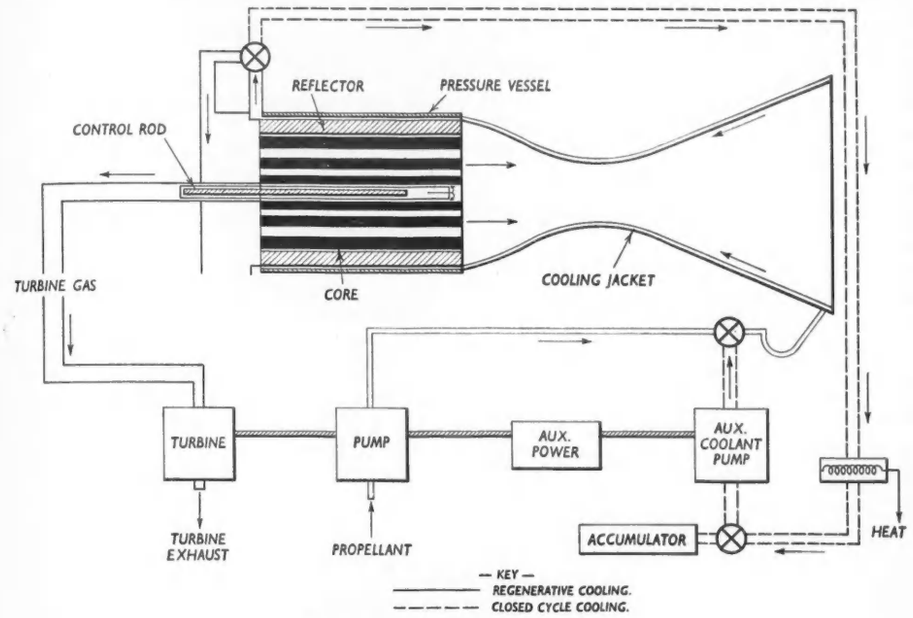


Fig. 13—Dual thrust nuclear rocket

of heat transfer, flow-control and safety problems, using gaseous hydrogen at a temperature of about 2200 deg. Cent. Later versions, "Kiwi-B," "Kiwi-C," will use liquid hydrogen at about 1000 lb per square inch pressure. There are many problems to be overcome such as controls, valves and switches to operate with hydrogen at high temperature and pressure, and there are others associated with radiation environment at low temperatures. Mass ratios expected from this type of rocket are in the order of 0·75 to 0·80 and the reactor should develop about 20–30 lb thrust per pound of total engine weight.[57] Flight tests of the later versions developed from the "Kiwi" programme may be launched during the late 'sixties with "Nova" as a booster. Whether nuclear fission rockets will ever be used for first-stage propulsion or only in space may not be known for a considerable time. It has been admitted that a launching site used by a nuclear rocket first stage would be unusable for several months and separations between sites exceeding half a mile might be necessary.[58] In space there will be other technical problems associated with thrust control, manœuvrability, starting, stopping and (perhaps) returning to earth. For manned missions, the shielding weight is important. Dr. Wyatt calculated a shielding weight of 1000 lb load per person for a large rocket, but recent developments of beryllium-plastic foam sandwich suggest that a lighter alternative may be possible.

It is quite clear, in spite of security restrictions, that the American nuclear rocket programme has high priority and presumably has assisted the development of liquid hydrogen techniques necessary for the chemical rockets.

Electric Rockets

Electric rockets derive thrust by the acceleration (by electro-magnetic or electrostatic means) of ions or ionised plasmas to velocities of the order of 10km per second. The measure of propulsive efficiency, specific impulse, is

$$\frac{T}{f} = \frac{\text{Thrust}}{\text{Weight of fuel per second}}$$

$$= \frac{\text{Exhaust velocity}}{\text{Terrestrial gravity}} \text{lb seconds per pound.}$$

i.e. in the region of 1000–10,000 much, superior to chemical rockets. The electrical emission currents needed to produce the same thrust levels as chemical rockets would be of the order of millions of amperes, hence such systems can only be operated continuously at much lower thrusts, providing typical accelerations in vehicles of 10^{-3} or 10^{-4} g. For these two reasons electric rockets are suited only to spaceflight. Theoretical work has been increasing in volume in 1959;[59, 60] many industrial groups have been breadboarding several types of systems, and work appears to have started on an experimental flight engine.[61]

Fig. 14 illustrates the principle of the plasma jet in which electrical energy in an arc is converted into the kinetic energy of a jet formed of ionised gas, usually air, argon or water. Temperatures are commonly 10,000 deg. Cent. An ion rocket requires a source of power, means of ionising a substance (propellant), and an accelerator. Two possible systems are shown in Fig. 15, either using a nuclear power source or solar energy. In the former a large radiator is required as part of the thermodynamic cycle of the turbine.

Unlike the chemical rocket, in which specific impulse is decided within fairly narrow limits by the propellants chosen, the electric rocket can be designed to have a specific impulse within a very wide range, e.g. 400 to 20,000 lb seconds per pound. This arises from the separation of the processes of power generation and acceleration of the working fluid, which are a combined process in a chemical rocket. In a chemical rocket the propellant weight is large and the engine weight small, hence the highest specific impulse is the criterion. In electric rockets the heavy generating plant weight can exceed that of the fuel and hence the optimum design will depend on the flight time and on the specific impulse. Specific impulse improves with exhaust velocity; this is increased by raising the accelerating voltage, which demands higher deadweight. Therefore, as plant weight goes up, fuel weight comes down and, hence, for a given mission there is an optimum specific impulse.

Camac gave relevant figures for a round trip to a lunar orbit:[62]

Trip time (days)	10			30			100		
	Low	Optimum	High	Low	Optimum	High	Low	Optimum	High
Specific impulse, lb secs/lb ...	600	800	1,300	600	1,700	4,000	600	3,000	15,000
Payload/weight	0·18	0·19	0·10	0·30	0·48	0·23	0·35	0·69	0·2

(Total power plant weight 40 lb per kilowatt)

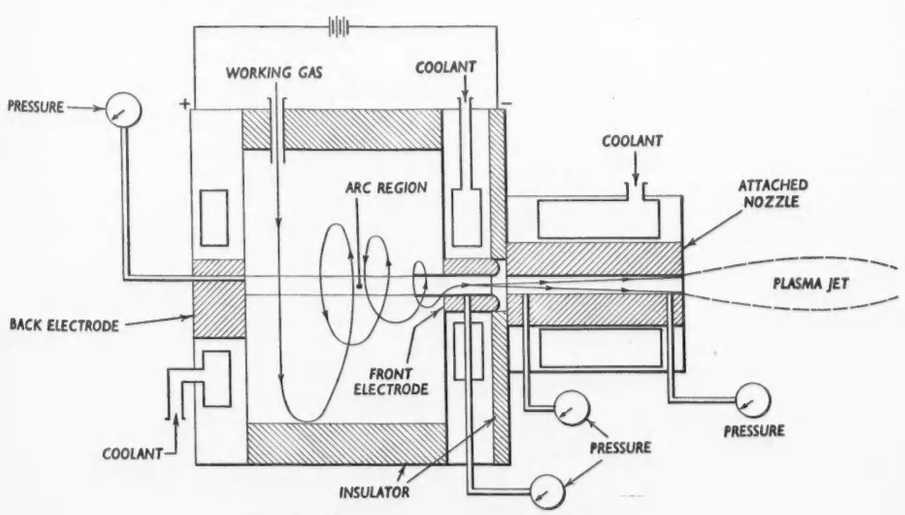
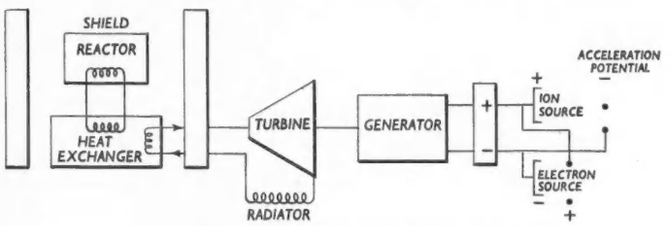


Fig. 14—Electric arc argon plasma jet

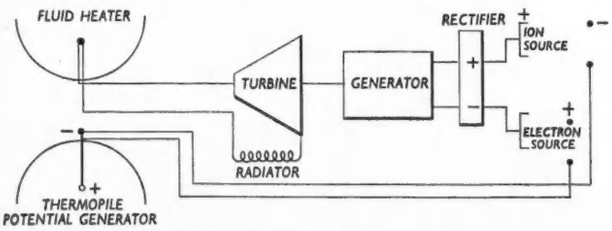
Different sub-types of electric rockets provide different specific impulse ranges, so an initial choice of sub-type may be made by considering the flight time desired. On a moon flight, for example, crew and cabin problems would be likely to increase disproportionately above trip times of ten days, and hence the lower specific impulses of 800–1500 might be selected. Plasma jets are suitable for this range of specific impulse. Higher exhaust velocities than these are provided by magnetohydrodynamic accelerator types giving 2000 to 15,000 lb seconds per pound S.I., and still higher values can be had with electrostatic ion rockets whose S.I. exceeds 10,000 lb seconds per pound.

Rockets generating thrust by heating a working fluid are more efficient with low molecular weight fluids. Ion rockets waste power if the exhaust contains lightweight ions or electrons.[63] In practice, suitable characteristics are found with those elements of the

highest possible atomic or molecular weight which form singly-charged ions. High atomic weight alkali metals have the most promise,[64] such as Cesium (atmospheric weight 13·29) and Rubidium (atmospheric weight 85·5). The former will ionise with 100 per cent efficiency in surface contact with tungsten over the temperature range from 925 deg. to 1760 deg. Cent. Great emphasis is now being placed on the engineering of these ionisation systems, particularly to avoid



NUCLEAR-POWERED ION ROCKET ENGINE DIAGRAM.



SOLAR-POWERED ION ROCKET DIAGRAM.

Fig. 15—Typical ion rockets

deterioration of the ionising surface[65] and also in the design of accelerating electrodes for the ion currents and the dissipation of electrons (generated in the ionising process) into the wake without recombination.[66]

Many American companies had practical laboratory engines on test in 1959. Rocketdyne have tested an ion thrust chamber in the laboratory capable of delivering 0·1A of cesium ions.[67] Experience is being acquired of the novel equipment needed to assess the performance of this type of unit. Rocketdyne feel that a (space) flight ion engine could be made within three years. Electro-Optical Systems, Inc., of Pasadena, has been awarded a U.S.A.F. contract for an ion rocket engine.[61] Work has already started on a 0·002 lb thrust cesium unit and the eventual target is for a thrust of 0·1 lb. Much engineering development still remains to be done on the power sources and electrical generation[68] systems, whose present large size and weight will make the launching of large electrical rockets a matter for the big boosters of the 1970s rather than those of the 1960s.

Further theoretical work has been published recently on photon rockets.[69] Basically, this class of rocket offers a theoretical promise of unbelievably high specific impulse (30×10^6 lb seconds per pound), but the conversion of significant amounts of matter‖ to light energy requires immense temperatures, so that it is hardly possible to visualise a suitable rocket chamber. Although experimental physics directed to this problem is under way, it is a little early for engineering interest and no dates have yet been quoted for a working prototype.

Comparison of Rocket Systems for Space Applications

Arguments for[70] and against[71] solid rockets for spaceflight continue: the performance comparison is broadly as in Fig. 10. Increased space payloads need very large solid rockets with thrusts up to say 4,000,000 lb, 200,000 lb in total weight, 60ft long by 8ft diameter. In such very large solid rocket boosters there are problems of supporting the large mass of semi-plastic propellant, which may be overcome by a technique of bar reinforcement analogous to that used in structural concrete. Steps have been already taken by Thiokol to provide 1,000,000 lb solid rocket test stands. The question of recoverability intrudes into simple performance comparisons and has been answered by proposals for manned air-breathing first steps. Electrical rockets do not appear very suitable for most earth-moon flights, but they do seem attractive for Mars flights, for example, and it is possible to make comparisons for longer duration voyages between several systems. Kraemer and Harson of Rocketdyne presented such a comparison to the A.S.M.E. in March, 1959.[72] Six alternative systems were considered to establish an instrumented vehicle in a Martian satellite orbit—starting from a 300 mile earth satellite orbit at a weight of 25,000 lb. The relative performance is indicated by the payload weight in the Martian orbit, viz.:

System	No. of Stages	Specific impulse, lb/sec./lb	Payload weight, lb
Solid chemical	3	274	1616
Hybrid (chlorine-trifluoride/lithium hydride)	2	310	2761
Storable liquid (nitrogen tetroxide-hydrazine)	2	310	2867
Cryogenic (fluorine-hydrogen)	2	405	4018
Nuclear (hydrogen)	1	1080	6295
Ion...	1	9000	8000

Apart from showing the theoretical superiority of the ion system this paper drew attention to temperature-storability problems in space. Storable liquids should not reach too low a temperature, and the vehicle would be orientated towards the sun. Cryogenic tanks would have to be carefully insulated from solar heat. Radiation shields could assist to an extent that boil-off would be negligible.[73] Driscoll of the Linde Company gave designs and weight estimates for low pressure tankage of liquid hydrogen, oxygen and fluorine for space vehicles. In a typical example, an uninsulated tank for 7360 lb of liquid hydrogen would evaporate completely in just over half an hour at ground level. In space at a temperature of −73 deg. Cent. the evaporation rate would be 0·4 per cent per day with an insulation thickness of 0·375in. With solar shields this could be substantially reduced. Typical tank weights were given as 0·13 lb per pound of hydrogen.

A large ion rocket system poses interesting new engineering problems. In March, 1959, N.A.S.A. published[74] system studies of a 700ft long ion vehicle for manned Martian flight. The power of 20,000kW was produced from a nuclear turbo-electric plant using sodium vapour as a working fluid. The overall power plant weight was estimated to be 6 lb per kilowatt.

‖ A hand torch in space would generate a velocity as a result of the momentum of its light beam. This would only be about 10^{-4}m per second, corresponding to a fractional reduction of mass of 10^{-11}

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(To be continued)

Margam "B" Power Station

To satisfy the requirements of the additional blast-furnaces, coke ovens and steelmaking plant incorporated in the latest expansion scheme of the Steel Company of Wales, it was estimated that a further 200,000 lb per hour of steam would be required. From consideration of the economics of the problems involved it was decided to install a Benson pattern boiler having a rating of 240,000 lb per hour of steam at 3300 lb per square inch and 1060 deg. Fah.

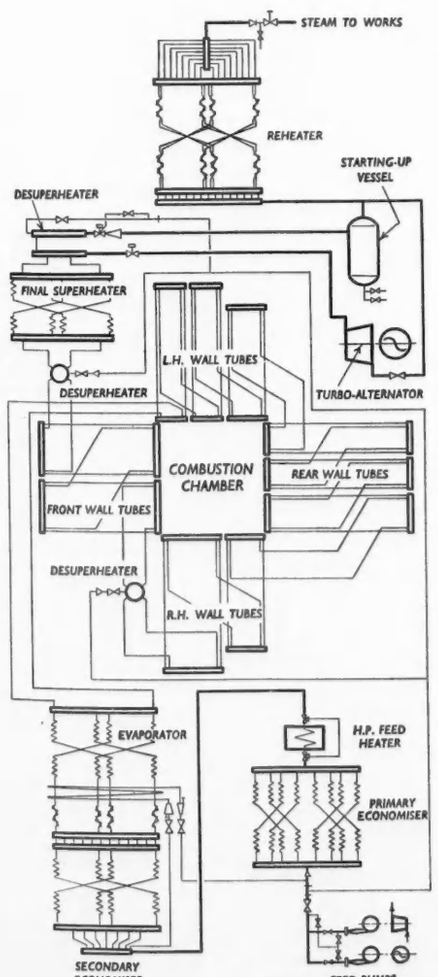
FOR the extensions planned by the Steel Company of Wales, Ltd., at its Margam and Abbey Works, involving blast-furnaces, coke ovens and steelmaking plant, it was estimated that an additional quantity of steam amounting to about 200,000 lb per hour would be required for driving turbo-blowers for the furnaces, for generating electrical power and for processing.

Current requirements for power are met by two power stations, both of which generate steam at 625 lb per square inch and 820 deg. Fah. In the "A" power station are five boilers having a rating of 100,000 lb per hour, fired by blast-furnace gas or fuel oil, and supplying steam to two back pressure and two condensing turbo-alternators and three back pressure centrifugal turboblowers. Steam from the one 200,000 lb per hour boiler in the "B" power station feeds one pass-out condensing turbo-alternator and one condensing axial flow turboblower. Two schemes were put forward for providing the additional steam; one was to install another boiler in the "B" station similar to the existing unit, and the second was to install a "topping" installation consisting of a Benson boiler and back pressure turbo-alternator. The latter scheme was adopted after careful examination of the overall efficiency, possible savings, comparative costs and its practicability.

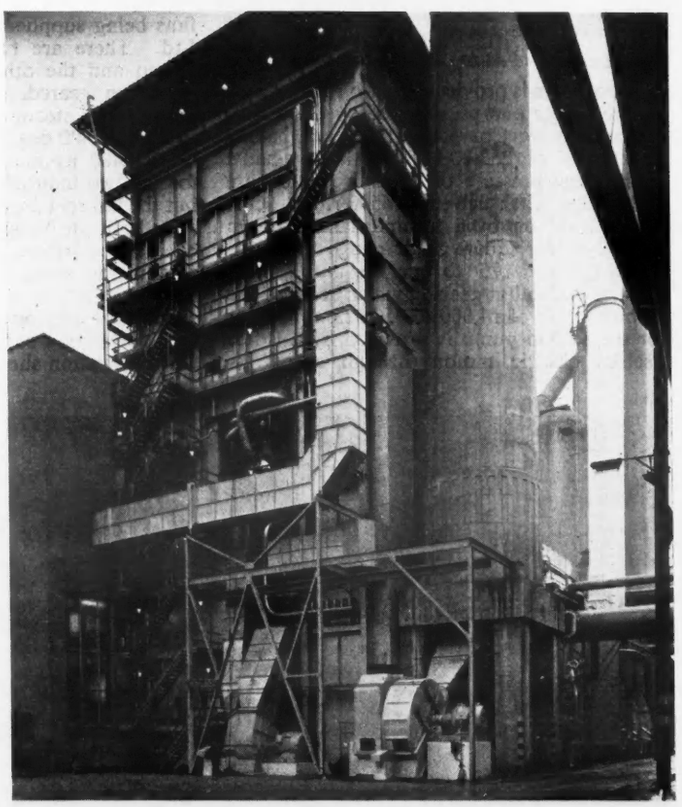
Generating capacity of the existing plant at 30MW met only half the normal demand and one-third the maximum demand, so that the addition of a critical pressure boiler and back pressure turbo-alternator which would produce another 9·5MW of electrical power meant a considerable saving. Optimum operating conditions of 3300 lb per square inch and 1060 deg. Fah. were adopted, based on a thermodynamic study and a steam flow of 240,000 lb per hour.

The O.T. Boiler

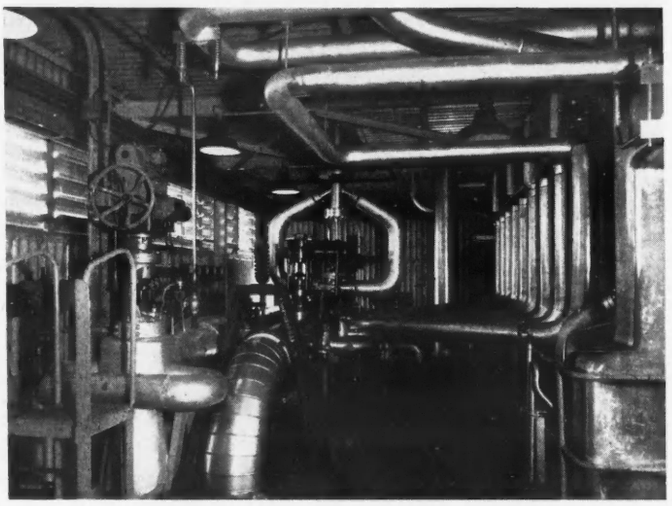
To supply steam at the pressure and temperature required Simon Carves, Ltd., has designed and built a water-tube forced-circulation boiler in which the feed water is heated, evaporated and superheated in a single passage through a number of tubes arranged in parallel. In this design of boiler, which is of Benson pattern and of which the original design was based on the principle that water at the critical pressure needs no latent heat for conversion into steam, the heating surfaces consist of small bore tubes. These are proportioned so that as much as 85 per cent of the feed water is evaporated in the "radiant evaporative section" sited in the hottest zone of the combustion chamber. From this point the steam and water mixture passes through a "transition section" in a zone of lower flue gas temperature where the remaining water is evaporated and the first stage of superheating takes place. The steam next passes through the radiant superheater, in the

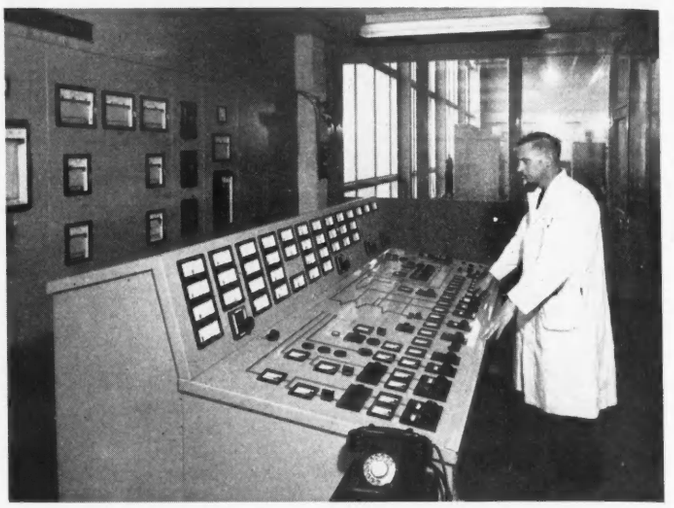


Flow diagram of the once-through forced circulation boiler



Outside view of the O.T. boiler of 240,000 lb per hour maximum rating





(Left) Superheater outlet collecting points, showing safety valves and main by-pass overflow valve (Right) Control panel for the O.T. boiler and high-pressure turbine

upper part of the combustion chamber, followed by the convection superheater.

The boiler now in service at the Margam "B" power station, of which an outside view and a flow diagram appear on page 101, is the first O.T. (once through) unit to be built commercially in this country and the following are the particulars of the steam conditions :

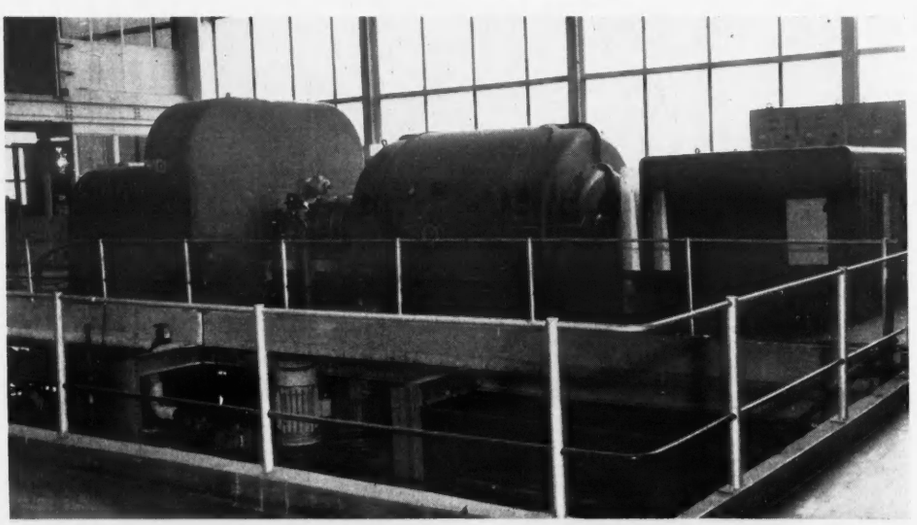
Steam pressure at superheater outlet ...	3300 lb per square inch gauge
Steam temperature at superheater outlet...	1060 deg. Fah.
Feed water temperature at economiser inlet	280 deg. Fah.
Continuous maximum rating	240,000 lb per hour
Quantity of steam to the reheater	205,000 lb per hour
Steam pressure at reheater inlet	650 lb per square inch gauge
Steam temperature at reheater inlet... ...	675 deg. Fah.
Steam pressure at reheater outlet	628 lb per square inch gauge
Steam temperature at reheater outlet ...	836 deg. Fah.

Feed water is provided by two ring-section, thirteen-stage pumps, supplied by the K.S.B. Manufacturing Company, Ltd., each having a capacity of 253,000 lb per hour against a discharge pressure of 4700 lb per square inch gauge when driven at 4500 r.p.m. One pump is driven by a turbine, taking steam at 600 lb per square inch gauge and discharging at 175 lb per square inch, through reduction gearing which reduces the turbine speed of 14,000 to 4500 r.p.m. Power for the second pump is provided by a Bruce Peebles electric motor through speed increasing gearing which raises the 1500 r.p.m. of the motor to 4500 r.p.m. Associated with the pumps are two Weir feed heaters, the l.p. unit being fed with steam at 15 lb per square inch gauge to raise the temperature of the feed water from 90 deg. to 200 deg. Fah. Steam at 650 lb per square inch gauge is supplied to the h.p. heater, which heats the feed water at full boiler pressure from 376 deg. to 487 deg. Fah.

The boiler is arranged to burn blast-furnace gas, having a gross calorific value of 92 B.Th.U. per cubic foot at 32 deg. Fah. and 30in Hg, and/or fuel oil of 18,000 B.Th.U. per pound gross calorific value, and operates on both forced and induced draught, the fans being supplied by J. Howden and Co., Ltd. There are two f.d. fans, one motor driven and the other driven by a double-reduction geared, single-stage impulse turbine, taking steam at 600 lb per square inch gauge and 800 deg. Fah., the speed of the fan being 1480 r.p.m. The drive arrangements for the two induced draught fans are similar but the fan speed is 985 r.p.m.

As built the boiler has four gas passes, each behind the other; the first consists of the combustion zone, of which the four walls form the radiant superheater, with the first evaporator section above, followed by the final convection superheater in two sections. Our illustration shows the superheater outlet collecting points. Above is a further evaporator surface, in three sections, where the transition from water to steam occurs. Reheater sections, each consisting of two banks of tubes, arranged in parallel from the second pass, while secondary economiser sections arranged in parallel and each consisting of three banks of tubes form the third pass. The fourth pass consists of a secondary tubular air heater with primary economiser sections arranged in parallel, each consisting of four double-flow banks of tubes, followed by a primary tubular air heater. Final steam pressure is governed by the feed pump delivery head, which overcomes the resistance of boiler and superheater and which can be varied to permit operation at less than design pressure, a facility which is of help in starting up the main turbine. To maintain a balance between the superheater temperature and the reheater steam temperature, when burning oil fuel, a Howden gas recirculation fan is mounted, driven at 1480 r.p.m. by a 114 h.p. motor and rated to handle 32,700 cubic feet per minute of gas at 350 deg. Fah. Control of the reheater steam temperature is by dampers, in the upper rear wall of the first pass, which regulate the gas flow, firstly over the upper evaporator banks or partly by-passing these banks and flowing over the reheater banks. Since water flashes into steam when the correct temperature is attained, no steam release surface is required, so that the boiler has no drums and the heating surface consists of tubes of 1¼in to 1½in o.d. welded to each other and to headers. For feeding the deaerator there are two Mather and Platt lift pumps, one turbine driven and one electrically driven, each capable of delivering 240,000 lb per hour against a discharge head of 125ft when driven at 1460 r.p.m. The two Drysdale extraction pumps are both electrically driven and are rated at 240,000 lb per hour against a discharge head of 30ft.

A Permutit mixed-bed "Deminrolit" polishing unit treats 240,000 lb per hour of demineralised water or condensate to ensure the following quality : total dissolved solids less than 0·5 p.p.m. ; silica less than 0·05 p.p.m. ; a pH value of 7·0 and conductivity of less than 0·5 reciprocal megohm.



High pressure turbo-alternator

Boiler Controls

As already mentioned, the boiler can be fired by blast-furnace gas, or oil or any mixture of these fuels. However, since the supply of blast-furnace gas is subject to

variation due to demands of the plant, the total fuel input is maintained by an automatic compensating flow of oil fuel. This is achieved by measuring the quantity of each fuel supplied to the combustion chamber, and regulating the Howden forced draught fans to supply air to the quantity required for both fuels. The turbo-alternator is pressure governed, and the boiler output is varied by an adjustable load setter, the alternator being supplied with more or less steam according to that output. The boiler load is controlled by the feed pump output and the final steam temperature is related to the fuel/feed water ratio associated with a trimming control from two stages of spray desuperheaters.

The boiler can be auto-manually operated, when actuation of the valves, &c., is, by electric motors controlled by switches at the control desk, or automatically controlled when the output is adjusted by the load setter. This consists of a series of rheostats, driven by a pilot motor, which signal load changes to the fuel controller, and later to the feed water and steam temperature controller. Our illustration shows the control panel for both boiler and turbine.

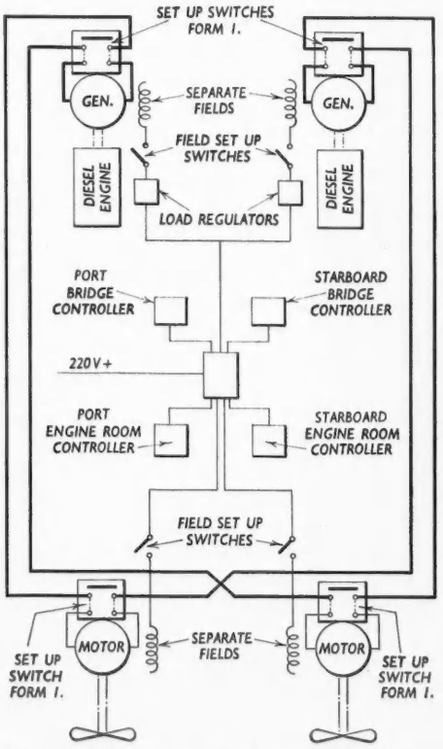
Back Pressure Turbo-Alternator

The Richardsons Westgarth high pressure back pressure turbo-alternator set, illustrated opposite, has a maximum output of 9·5 MW at 10,500V/11,500V with the alternator, which has a power factor of 0·7 lagging, driven at 3000 r.p.m. through Allen double-helical speed reducing epicyclic gearing by a turbine supplied with 240,000 lb per hour of steam at 3000 lb per square inch gauge and 1050 deg. Fah., and exhausting at 650 lb per square inch gauge and 670 deg. Fah. The turbine rotor runs at 9500 r.p.m. and has one row of impulse blading followed by fourteen rows of reaction blading machined from solid bar. The dummy piston carries thirty-nine gland strips and there are thirty gland strips at each end of the rotor, which has a length of 6ft 6in between bearing centres and weighs 1300 lb.

The double walled turbine cylinder consists of an inner cylinder and a flanged outer cylinder and has a weight of 4·5 tons. The inner cylinder is divided at the horizontal joint, the halves being held together by shrink rings, while the outer cylinder is of conventional flanged design with the exhaust steam connection in the middle of the cylinder bottom half: thus the exhaust steam sweeps the outside of the inner cylinder so that the shrink rings remain tight. Four integrally cast palms support the inner cylinder within the outer, which is supported in front and rear bearing keeps by eight straps bolted to both cylinder and keeps. The main glands have two pockets from which steam at 175 lb and 15 lb per square inch gauge is tapped, and main steam is supplied to two integral chests, one at each side of the turbine at the front end. Each chest cons ists of a single-seated combined stop and emergency valve and two single-seated nozzle valves from which the steam is delivered through the outer cylinder by piston pattern connections to four cast nozzle segments in the inner cylinder. The chests, which are interconnected to permit load testing of the valves, are supported on linkages to compensate for expansion, and the steam joints at the valves are of modified Corwell pattern. A pump driven from the front end of the turbine supplies oil to actuate the valve servo-motors, and a second pump supplies the lubricating and governing oil. A centrifugal governor is mounted, and also an Askania regulator so that load can be governed by boiler pressure.

Diesel-Electric Tug "Llanwern"

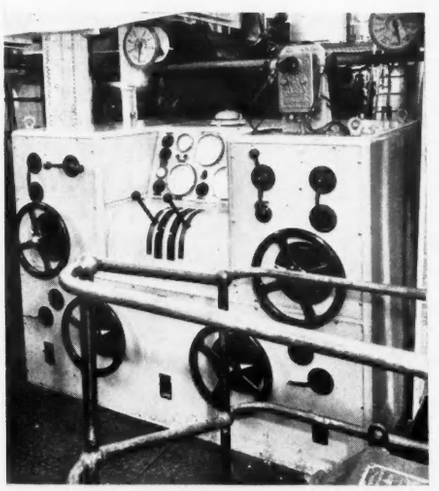
OUR illustration shows the twin screw tug "Llanwern," which has been built by P. K. Harris and Sons, Ltd., and handed over to the British Transport Commission for service at Newport Docks. The tug, which is of hydroconic form designed by Burness, Corlett and Partners, is of all welded construction and has the following dimensions; length between perpendiculars 85ft, breadth moulded 25ft 9in, depth moulded 11ft 9in and gross tonnage 160.



Diagrammatic arrangement of propulsion machinery

Propulsion is by twin screws driven by diesel electric machinery consisting of two Lister-Blackstone turbo-charged diesel engines having eight cylinders of 8·75in bore by 11·5in stroke and each developing 660 b.h.p. at 750 r.p.m. The engines are each direct coupled to a Brush three field, d.c. generator rated 440V, 1000A, and the power from each is taken to a Brush 550 b.h.p., 440V, 1000A, 1250 r.p.m. propulsion motor. The final drive is through a Hindmarch-M.W.D. single-reduction gearbox to give a propeller speed of 210 r.p.m., and the tug a speed of 12 knots. The main generators and the propulsion motors have their armatures connected in a series loop and by means of a set-up switch provided for each armature and located in the control cubicle any individual machine can be cut out of the propulsion loop. Control is by direct variation of both the propulsion motor and main generator by matched adjustments to the fields of these machines. A dash-pot device incorporated in each controller provides a small time lag so that the controllers can be swung from full ahead to full astern without damage.

A Brush "Load Regulator" is connected with each engine and this equipment automatically reduces the load on an engine, should it become overloaded, and automatically matches engine loading and generator working output to a wide range of working conditions, including running on one engine. Control is by Bloctube operation from the bridge and from an engine room console, of which we include an illustration. This has four set-up switches and associated field switches; port and starboard power control handles, bridge or engine-room control selection; an excitation supply switch which enables excitation to be obtained from port or starboard auxiliary generators or the harbour set; and three excitation supply circuit breakers. Since the main engines run at constant speed they are used to drive two 46kW, 110V auxiliary generators, either of which is of ample power to satisfy normal demands.



Engine-room control console

With this form of drive the propeller can be going astern from full ahead in five seconds and the ship be brought to rest within twenty seconds. For the majority of operations only one engine will be used, the second engine being required only for maximum power. With only one engine operating the tug has a running free speed of over 10 knots and can exert a bollard pull of 10 tons. Compared with the minimum speed of steady operation of about 30 per cent with mechanical drive, 10 per cent can be obtained with the diesel electric drive.

LETTERS AND LITERATURE

Letters to the Editor

STRUCTURAL STEELWORK AND BRITISH STANDARDS

SIR,—Correspondence on this subject draws attention to an important matter of principle in connection with British Standards in general and indeed any other standards of the same character.

The basic justification for standards is the great saving and convenience effected by minimising the number of sizes of components, e.g. nuts and bolts, without serious restriction for designers. If there were a rational method of determining standard sizes of bolts there would be no need for a standardising organisation as manufacturers would (perhaps) determine what those sizes were, and would use no others. There is in fact no rational method and so standard sizes must be fixed arbitrarily after taking existing practice into account. A committee is perhaps the best means of doing this.

But there has been a strong tendency to extend British Standards beyond this extremely useful field. For example, methods of estimating safe loads on components are published in British Standards; this has been done in the face of some opposition, on the excuse that it is " helpful " to the user of the standard. There is something in this, and there would be even more if it could be proved that such additional information were the very best that could be found. In actual fact it rarely is ; when it is not, its inclusion in a British Standard is positively harmful as its position there naturally leads the unwary to assume that it is as nearly correct as some great weight of accumulated experience can make it. If this ever happens, it is rare, because by the very nature of British Standards Institution committees every decision is affected by non-technical considerations that would be strenuously denied if anyone were to mention them. The experienced engineer recognises this and accepts the " helpful " parts of British Standards (even where not obviously faulty) with great reserve. The less mature engineer may not suspect that the presentation of an apparently purely technical matter may in fact be tainted by non-technical considerations and he may therefore be guided into inefficient methods or may waste much time in trying to make sense out of nonsense.

The British Standards Institution has a difficult task in trying to reconcile what are often warring factions, but although technical horrors in British Standards are usually in fact the outcomes of masterpieces of compromise they are not on that account any the less malignant to the unsophisticated reader. If British Standards were to be limited to their legitimate field they could be cheaper, an enormous amount of committee members' time could become available for other pursuits, and the young seeker for technical knowledge would be spared some nasty pitfalls. Failing complete exclusion of " helpful " information from British Standards, it should be accompanied by a prominent note stating clearly that there are probably better ways of doing the same thing.

W. A. TUPLIN

Sheffield,
July 11, 1960.

DISTRIBUTION OF SHEAR STRESS IN A BOX BEAM

SIR,—The author of the article " Distribution of Shear Stress in a Box Beam," in the issue of June 24, states " It is commonly assumed that in a symmetrical box beam, in which three webs are all of equal thickness, the bending shear force is divided proportionately, so that the average shear stress is equal to each web." It would be of interest to know in which branches of the engineering profession such sweeping assumptions are made ; certainly not in the aircraft industry, where multi-web box beams are widely used as the principal structure of wings.

One would have expected to find a reference to previous papers in this field, especially the well-known Aeronautical Research Council Reports and Memoranda No. 1669, " Some Features of the Behaviour in Bending of Thin-Walled Tubes and Channels " (Williams-1935), and No. 1751, " A Study of the Flexural Axis Positions for Certain Box Sections " (Williams and Fairbank, 1936). More recently, the Hardy Cross moment distribution method has been adapted to simplify the analysis of shear distribution in multi-web beams. A paper on this topic appears in the *Journal of the Royal Aeronautical Society* dated February, 1954.

W. G. HEATH,
Asst. Chief Structural Engineer
A. V. Roe and Co., Ltd.,
Manchester,
July 5, 1960.

EAST LONDON HARBOUR

SIR,—I am most surprised to read the article on page 880 of THE ENGINEER of May 20, 1960. Your correspondent has missed the point of the big blast in the East London Harbour. Excavation in the dry took place and the walls were built on solid rock and the level of the new dock floor was taken some feet below the finished level, as shown in the second picture, leaving the retaining wall of rock as narrow as possible. When this was completed the charge of 25 tons was fired, as seen in the first picture. The force of the blast and the inrush of water carried the shattered rock into the new basin which, as I have said, was purposely made deeper than the finished depth. All that remained to be done was to dredge any isolated loose rock that was left behind. At no time was the area dewatered after blasting.

R. D. WILLIAMS

East London,
South Africa,
June 14, 1960.

PADDLE STEAMER " FRESHWATER "

SIR,—Having read Mr. Jellett's letter published on July I, feel I must hasten to reply, and assure you that my statement regarding P.S. " Freshwater " was not " incorrect."

I am well aware that M.V. " Farringford " is paddle propelled, indeed I had the pleasure of describing her at some length in your pages when she entered service, but she is *not* a steamer, and accordingly I think you will agree that " Freshwater " was the last of a long line of paddle *steamers* that plied between Lymington and Yarmouth, and for many years served Totland and Alum Bays.

The " Farringford," of course, is a motor ship.

G. W. TRIPP.

Fareham, Hants.
July 7, 1960.

Book Reviews

Armour. By RICHARD M. OGORKIEWICZ. Stevens and Sons, Ltd., 11, New Fetter Lane, London, E.C.4. Price 45s.

ARMOUR is a big book on a big subject. It is a comprehensive account of armoured forces and their equipment, essentially tanks. The engineer is always inclined to believe that building the machine is the difficult bit, and that the master, driver, operator, or programmer, as the case may be, should have no difficulty in using it. This thorough and detailed study of the way the tank has been used shows that the opposite can be the case not only in a tactical situation but in organising before the conflict. The viewpoint is that of the fighter rather than the builder, the reader being expected to understand " fire and movement," to comprehend the significance of applying stabilisation to the armament, and to appreciate that the armoured fighting vehicle differs from the remainder of army weapons in its power of target acquisition, the ability to find and fix as well as strike.

To the author, the two dominant elements of an army are the tanks and the infantry, and the important issue is how to combine the two. Exhaustive case histories of the major armies show how the level at which both elements are present has crept down and down from army to division to battalion, with the proportions of each fluctuating—but the author distinguishes sharply between this conclusion and the starting point, where each battalion of infantry had a number of tanks to support it, rather than to do its killing. Sometimes one could wish for even more detail in this by no means tedious record of organisation and re-organisation ; for instance, it is said of the United States Army World War II armoured division, which had two combat headquarters units to either of which any of the tank and infantry battalions could be attached, that for most of the tanks to be under one and most of the infantry under the other had the disadvantage " that each command tended to get involved in a private battle of its own." This is not evidently a disadvantage. If all the forces were committed in the same battle, one headquarters would be ample ; while it

is undeniable that, whatever establishments may say, some units will be best suited to exploiting rapidly developing situations, others to enduring prolonged set piece encounters, and perhaps yet others to dispositions where they can be supervised and supported, and it would seem wise to have an organisation with room for both the essential participants.

The author is a mechanical engineer, and naturally has not failed to study the weapons as well as the forces deployed. However, even in a book of 475 pages, the story of the development from one vehicle to the next can hardly be treated in engineering detail, and in some cases there is too little to show just why a tank was successful or the opposite. But the overall picture is treated convincingly, particularly, for instance, in emphasising the virtues of a minimum of *contemporary* projects, and in discussing how a programme can make the best use of a circumscribed industrial potential. This leads, naturally, to consideration of how much vehicles cost and why ; the author suspects that in some cases the price is high because such enterprises as Hispano-Suiza cannot afford to produce an item that is not in all respects unsurpassed—it is unfortunate for the reader and, perhaps, for this country, that the volume was printed too early to include an analysis of last year's decision in Britain to accept a range of multi-fuel engines too expensive to be standardised for all applications, particularly in the light of the author's grasp of the part that has been played in the past by commercially available components such as the Ford "T" and V-8 engines and the Cletrac transmission.

It should not be inferred that the designer's problems are not treated. The main themes, protective armour, engines, transmissions, and so on, are covered in a manner that should allow the layman to appreciate why there are such different solutions to seemingly similar problems, and should also prove enlightening—how many realise that the tank engine built by Nuffield in 1939 was a World War I aero-engine of United States design ?

Since the main history has been traced in terms of the tank, further chapters cover the development of the armoured car, the self-propelled gun, and the armoured personnel carrier. The author is quite clearly of the opinion that the defence against the tank is the tank, but it could be argued that a tank for defensive roles could gain in mobility, and hence effectiveness, by sacrificing the turret and the all-round armour that are justified during the break-through and exploitation phases. It would also have added interest to mention the use found for tanks in the adverse conditions of Korea, where they acted as armoured field guns in emplacements that had been pin-pointed for counter-battery fire !

If serious fault is to be found with this text, it is that the concentration on armour goes beyond the degree of independence such a force in fact enjoys in war. One brief reference to the possession of "organic transporters" by a German formation is the only hint that tactical mobility does not imply strategic mobility, and surely does injustice to such mighty tools as the $6\times6+8$ Pacific articulated truck-trailer combination, which, with its facility of self-loading over the trailer wheels, compares instructively with the normal control six-wheelers of civilian origin to which the British army has for so long been confined. Similarly, it is unjustifiable if convenient to assume that an armoured force should consist only of surface vehicles ; the attractiveness of refuelling from the air alone would justify a long, hard look not only at ground effect machines but at V.T.O.L. or even S.T.O.L. aircraft.

Those who recall, in our issue of August 21, 1959, the article "Sixty Years of Armoured Car Development," will be in no doubt of the author's ability both to encompass his subject matter and to present large masses of facts in persistently readable prose. In this volume his text is augmented by a small collection of photographs and a well-designed if not eclectic index. Purchasers in this country can revel in the knowledge that publication in the United States is still three months in the future.

Nuclear Reactor Stability. By A. HITCHCOCK, B.A., Ph.D., A.Inst.P. Temple Press, Ltd., Bowling Green Lane, London, E.C.1. Price 12s. 6d.

IN this book, No. XI in the series of "Nuclear Engineering" Monographs, the author explains how instabilities can arise when the variables, such as neutron flux, coolant flow and temperature, depart from their normal steady-state values and derives, in an elementary way, criteria for the various kinds of instability. To keep the subject within bounds the treatment avoids the specialised techniques of control theory ; accordingly, control problems as such are discussed only briefly.

The book opens with an introduction to the dynamics of power reactors which outlines the physical conditions for stability. Then a chapter on the stability of dynamic systems leads up to methods for the treatment of spatial variations in a reactor and includes examples of unstable systems. Temperature instability, associated with a positive moderator coefficient, which can affect any reactor with a solid moderator containing some plutonium, is then considered ; a specific example of a Calder Hall type of reactor is examined. Zenon instability, associated with xenon poisoning, can arise in any thermal reactor, and it is discussed in the next chapter, the mathematical treatment being similar to that of temperature instability. By applying this analysis to the same Calder Hall type reactor it is shown that xenon instability can readily be avoided by control rods which penetrate well into the reactor. Voidage instability, which is a characteristic of steam voids in a boiling water reactor, is also dealt with. The final chapter, on control of instability, summarises the principles but, as already indicated, does not attempt to discuss the actual design of control systems.

Inevitably the treatment of the subject is mainly mathematical and the author is to be commended on the care with which he has tried to keep the notation consistent throughout the book and, where possible, consistent with other volumes in the same series. This monograph should appeal strongly to students, research assistants and engineers, who seek to acquire a broad understanding of a subject outside their immediate field of study, and are not interested in the depth of treatment given in specialised textbooks or papers.

Singularitätentheorie der Flügelgitter. By LUDWIG MEYER. Mitteilungen aus dem Institut für Aerodynamik an der Eidgenössischen Technischen Hochschule Zürich, No. 26. Verlag Leemann A.G., Arrenzstr. 20, Zürich, 34. Price Sw.Fr.28.

THE present paper deals with the design of turbine blade cascades for axial-flow turbomachines, according to the theory due to Ackeret, based on singularities (sources, sinks, fixed vortices) and developed in particular for closely spaced finite cascades. The effect of changing the angle of inclination is described and on the basis of these considerations a scheme of numerical calculation is set up. This is done in such a way that even those unfamiliar with the underlying theory can carry out the work step by step. Although with the aid of manual calculating machine a complete set of calculations requires under twenty-five hours, this would still be excessive if a whole series of cascades were to be investigated, and a programme for electronic calculations is therefore outlined. An iterative method is given for calculating blading with the most favourable pressure distribution. The accuracy of the calculations is checked by comparison with experiments carried out in the electrolytic tank.

Books of Reference

Dictionary of Civil Engineering and Construction Machinery and Equipment. English : French. Contractors Record, Ltd., Lennox House, Norfolk Street, Strand, London, W.C.2. Price 65s.—The compiler of a technical dictionary has an unenviable task, even when he is concerned with two such near neighbours as France and England. The practising professional engineer, experienced in either the theory or the practice of the technology concerned, is scarcely likely to find the time, if he has two languages at his command, to undertake such a task ; and even for him it is difficult enough to keep up with the vast progress now apparent over such a wide field as is covered, for instance, by this dictionary. We give this apology in defence and not in vitiation of the dictionary under review, for while it is doubtless possible for the specialist user to "pick holes" in it, it gives an abundance of useful information, sufficient to unravel the problems of translation which most civil engineers are likely to meet. The fields which it covers, as listed by the publishers, are road and airfield construction ; soil mechanics ; dams ; harbours ; tunnels ; foundations ; bridges ; prestressed concrete, construction materials, &c.

Water Engineers' Handbook, 1960. Edited by D. Wilkinson and N. Squire. The Colliery Guardian Publishing Company, Ltd., 30 and 31, Furnival Street, Holborn, London, E.C.4. Price 20s.—The usual layout of this standard work of reference is retained in the 1960 edition, but its content is affected, even more than in the last five years, by the accelerated pace of regrouping of water undertakings. Two preliminary tables list regroupings in 1959 and in 1960, respectively, and together 168 undertakings are involved in these two tables ; sixty-two were transferred, wholly or partly, in 1959, and 106 were known to be due for transfer this year at the time the book was prepared. Details are given of fourteen new water boards.

Books Received

Engineering Drawing with Worked Examples. Vol. 1. By F. Pickup and M. A. Parker. Hutchinson and Co. (Publishers), Ltd., 178-202, Great Portland Street, London, W.1. Price 21s.

The Mechanics of Engineering Soils. Third Edition. By P. Leonard Capper and W. Fisher Cassie. E. and F. N. Spon, Ltd., 22, Henrietta Street, Strand, London, W.C.2. Price 30s.

Métrologie Général. Grandeurs, Unités et Symboles. Fourth Edition. Vols. 1 and 2. By M. Denis-Papin and J. Vallot. Dunod, 92, Rue Bonaparte, Paris (6e). Price Fr.680 each.

Industrial Electronics and Control. Second Edition. By R. Gerald Kloeffler. John Wiley and Sons Inc., New York ; Chapman and Hall, Ltd., 37, Essex Street, London, W.C.2. Price 80s.

Materials and Techniques for Electron Tubes. By Walter H. Kohl. Chapman and Hall, Ltd., 37, Essex Street, Strand, London, W.C.2 ; Reinhold Publishing Corporation, New York. Price 132s.

Atomic Energy in the Soviet Union. By Arnold Kramish. Oxford University Press, Amen House, Warwick Square, London, E.C.4, for Stanford University Press, California, U.S.A. Price 27s. 6d.

Particle Board Factory

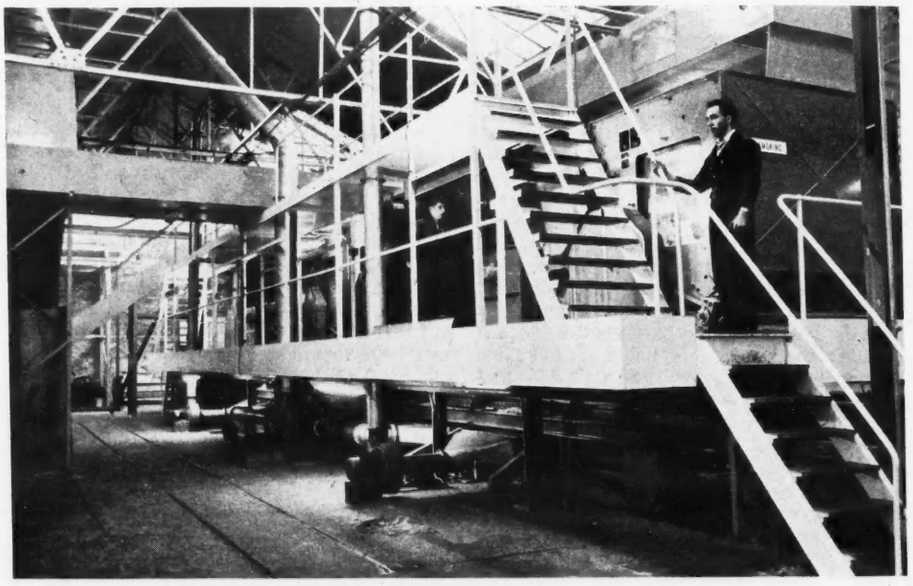
The expanding market for chipboard, with its non-warping qualities, lightness, strength and adaptability, prompted the formation of the Tyne Board Company, Ltd., to manufacture a high grade particle board and the building of a new plant, which is largely automatically controlled, alongside the existing plywood mill of an associated company, Tyne and Timber Veneers, Ltd.

IT was in 1937 that a plywood factory was established at Willington Quay and now alongside the older plant there has been built a factory to manufacture particle board. The new works, owned by the Tyne Board Company, Ltd., manufactures "Tybord" and was officially inaugurated by the Duke of Northumberland on June 27. As manufactured the material is a development from the original chip board, which made its appearance in 1943, and is made from wood chips of uniform size and thickness machined from coniferous timbers, combined with a resin adhesive. The three layer board is produced in three thicknesses, 12mm, 15mm and 18mm, and to a standard size of 9ft by 5ft 8in. It has a smooth surface, has non-warping qualities, is highly stable, takes a veneer, is resilient and water repellent, and can be worked in the same way as natural timber. The main particulars of the product are as follows: density 36 lb/38 lb per cubic foot; thickness tolerance $\pm 1 \cdot 5$ per cent; transverse breaking strain 650 lb; modulus of rupture 2875 lb per square inch; moisture content, ex-factory, 8 to 12 per cent; and water absorption after one hour immersion 6 to 9 per cent.

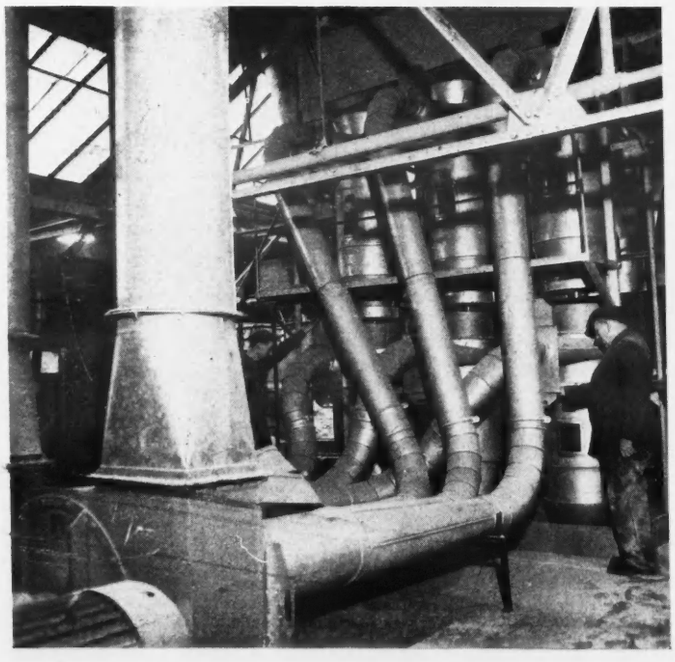
The plant, which is fully automatic, has been designed to produce 20,000,000 square feet of 18mm thick "Tybord" per annum and the design has been based upon a study of the processes and machinery employed in other countries. Before finally siting the machines a scale model of the factory was prepared so that adjustments of layout could be made to ensure the efficient use of space combined with ease of maintenance. The plant itself has been installed by the works maintenance staff.

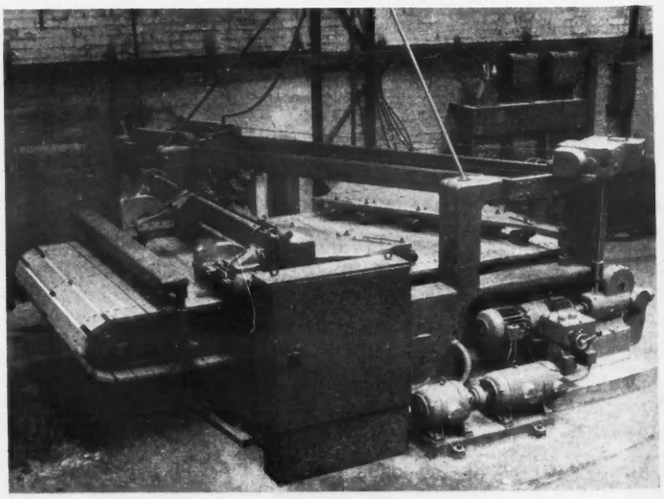
Raw material in the form of 2in to 8in diameter debarked logs is brought by sea from Finland, unloaded to stock at the company's wharf, and then passed to the chipping machines to enter the process. In one set of machines the logs are fed by gravity and in the other the logs are first cut to length and then fed to the machine where contra-rotating chains fitted with dogs force the logs on to the cutters. These are of ordinary high-speed steel and are dovetailed into the rotary cutting block so that they can be easily removed for grinding, an operation which has to be carried out at comparatively short intervals, the time depending upon the moisture content of the wood. Chips of 2mm thickness are cut for the outer layers and of 4mm thickness for the core, and both are fed to wet storage silos. From here the chips, in separate streams, are forwarded at a controlled rate to a battery of mills which reduces them to a predetermined and constant size before they are pneumatically conveyed to the oil-fired jet dryers. Here the chips are dried to the required moisture content: the angle of the flights can be adjusted to control the speed of flow as dictated by the initial and final moisture content.

The dried particles pass over vibrating screens, to extract the dust, and thence to an air suspension separator, illustrated herewith, in which the particles fall through venturis and the lighter particles are extracted by an induced-draught fan while the heavier particles fall to the bottom before being extracted. The two streams, the light particles for the face layers and the heavy particles for the core, are conveyed to bunkers from which they are forwarded in automatically weighed quantities to the glue



Four station spreader for forming the mattress





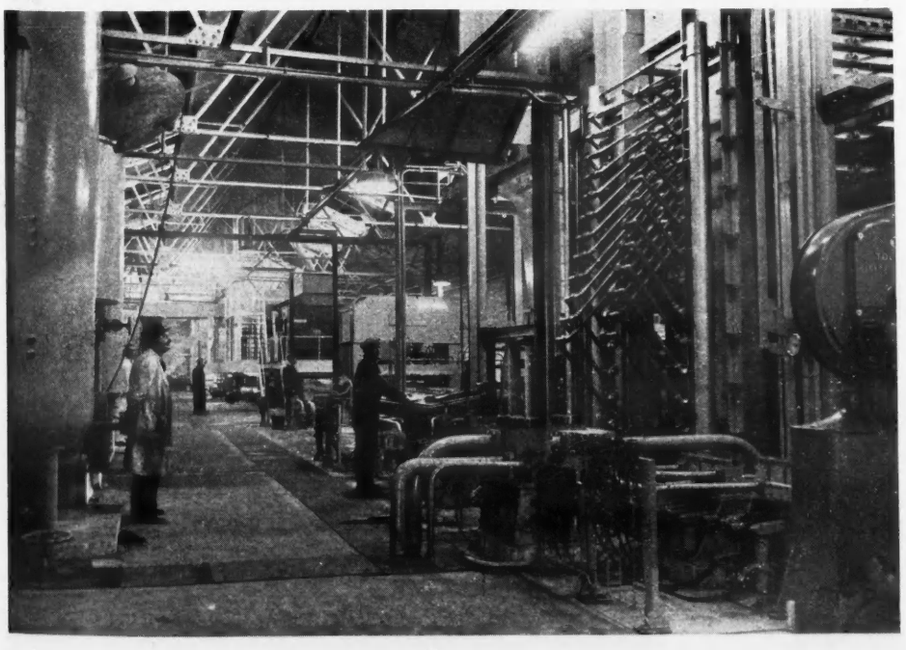
(Above)
Four-way sizing saw for squaring all four sides of a board in one operation

(Left) Air suspension separator for grading particles for face and core layers

mixers where they pass through a resin haze and receive an even coating. The particles are ducted to the Siempelkamp spreader which we illustrate, with the fine material being delivered to No. 1 and No. 4 stations and the coarse material to No. 2 and No. 3 stations ready for spreading to form the mattress, the first stage in the final production of the board.

The mattress is formed on an aluminium alloy plate which is sprayed before passing into the spreader, where measured quantities of particles fall on to short lengths of belting which feeds them to a throwing roller. The particles are evenly spread and have a free fall on to the plate. At No. 1 station fine material is deposited in the caul plate; coarse material, forming the core layers, is poured at No. 2 and No. 3 stations, while at No. 4 station the face layer of fine material is poured to complete the mattress. Surplus mattress material is collected and returned to coarse sections of the spreader. From the forming station the mattress passes under a fine water spray and enters a prepress where the thickness is reduced. Each mattress again passes under a fine water spray before entering one of the tiers of a twelve tier main press loader, and when each tier has received a mattress all the mattresses are transferred to the twelve daylight main press, seen in our illustration, where a pressure of about 200 lb per square inch is applied with steam heat at 150 deg. Cent. to cure the resin. Residence time is about seven minutes for 12mm thick board. After being cured, the mattresses pass one at a time into the unloader and then individually are conveyed to the point where the rough board is removed to storage and the caul, after passing through an air cooler, is returned to the spreader line. Subsequently, the boards are edge trimmed and cut to length in a Bottcher and Gessiner machine, which we illustrate, and then the faces are polished in two Carstens sanders. It is understood that the plant will be working twenty-four hours per day for six days a week, the seventh day being set aside for maintenance work, and that full production will be approximately 1500 boards per day. The problem of the disposal of sanding dust has been solved by evolving a method of burning it as fuel in the boilers. When oil is being burnt the sanding dust is blown into the furnace through an orifice and when the dust is burning the fuel oil is cut down until there is just sufficient to ensure ignition of the dust. The oil burner is interlocked with the f.d. and i.d. fans and the dust feed so that failure of the oil burner automatically shuts off the supply of dust.

The electrical control of the plant has a power supply of 440V 50 c/s from one 1500kVA transformer and all operations of the plant are in sequence so that should one machine fail all the remaining machines will empty themselves of materials under process. Brown Boveri equipment controls all the machines and processes involved in chip drying, spreading, and the mattress forming and processing stages.



Twelve daylight press and control console

Gas-Compatible Meter Diaphragms

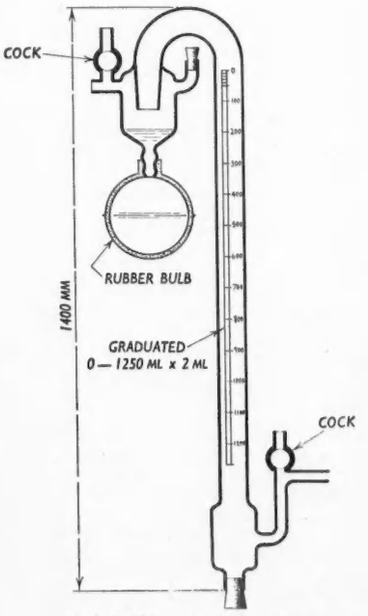
THE classical material for the diaphragms of gas meters is leather; leather was originally adopted because of the unique ability to accept three-dimensional deflection bestowed upon it by its composition, the complex protein structures being coiled into fibrils and the fibrils themselves twisted into fibre bundles with a three-dimensional weave. The inter-fibrillar spaces must be sealed in order to render the leather impermeable, and this is achieved by impregnating the leather with oil: the porosity of the leather is so fine that capillarity will retain the oil against pressures of the order of 12in w.g. The provision of oils to remain unaffected by the organic chemicals in the gas is, however, difficult, and there is a significant tendency for oil and gas to interact, a satisfactory oil being one for which an equilibrium condition is reached without the functioning being impaired. The fundamental weakness of such a solution, that it demands a stable gas composition, was forcefully demonstrated by the North American gas industry when they changed their domestic gas supply from coal gas to natural gas.

The original American gas made from coal had, in the main, a high relative humidity and was fairly rich in both saturated and unsaturated hydrocarbons. Amongst these volatile hydrocarbons were members of the benzole series which are extremely active solvents and which tend to be scrubbed from the coal gas by oils.

The suppliers changed to natural gas which was extremely dry and contained around 95 per cent methane, the remainder being the next simplest members of the paraffin series in gaseous form.

During the life history of American gas meters on coal gas—all of which used "bag" type leather diaphragms made from full grain New Zealand sheepskins and oiled with mixtures of oils according to the preferences of meter manufacturers and gas companies—the oil dressings had scrubbed hydrocarbons from the coal gas. The dressings had therefore become diluted, lost their viscosity and partly drained from the leather.

Thus the diaphragms were, in effect, dressed with oil plus condensates—in some cases mainly the latter. In areas where the gas supply had been very wet, water tended to be absorbed by the hydrophylic leather and gradually replaced the oil dressing, or, at best, formed an emulsion containing water, condensate and oil dressing. This effect was exaggerated in gas supplies containing small amounts of ammonia. The ammonia itself, by altering the *p*H of the leather, caused it to harden and shrink.



Soap bubble meter for gas flow

Additionally, coal gas supplies are notorious for the way their composition varies with climatic and economic conditions in summer and winter. If the original coal gas supplies had remained reasonably constant, in most cases equilibrium conditions would have been set up between the oiled diaphragms and the gas supply. Seasonal fluctuations prevented this and tended to exaggerate the undesirable extraction effects on the oil dressing. Nevertheless, some sort of rough equilibrium was established in districts served by individual coal gas supplies. When the Americans suddenly changed to natural gas, any semblance of equilibrium was completely upset. The dry gas acted like a dessicating agent and promptly removed the water and the volatile hydrocarbons. The result was that the leather diaphragms lost nearly all their dressing and then became dry and chemically hardened.

Because natural gas is normally extremely dry and contains no higher members of the various hydrocarbons, no powerful solvents of the benzole series and no injurious chemicals such

Five of the six meter-testing rigs ; the sixth is running on gas at 170 deg. Fah. and is enclosed in the far corner of the room

as ammonia and cyanide, disc type leather diaphragms function perfectly for almost indefinite periods. Nevertheless, the need to change the diaphragm when the source of the gas is changed may be unacceptable ; in this country, the manufacturers supply meters with a five-year guarantee under which they contract not only to supply, say, a new diaphragm, but also to transport and test the meter. This rather heavy liability represents an incentive to standardise at an early date a diaphragm that will be unaffected by coal gas ; equally, it demands that very comprehensive testing should have been undertaken to eliminate weaknesses that might lead to malfunctioning in service. It should be added that, in the case of meters used for determining a consumer's gas bills, protracted service trials also are mandatory for a new material.

In order to obtain test results in statistically significant quantities, the Metropolitan Leather Company, Ltd., Great Harwood, Lancashire, which supplies diaphragms not only to other member companies of the Parkinson Cowan Group but to meter manufacturers in many parts of the world, has established a diaphragm testing and research laboratory at its works. Physical testing is performed in an ambient atmosphere of 70 deg. Fah. and 70 per cent relative humidity. The most part of the equipment consists of six rigs for circulating various gases through large numbers of meters ; five of these rigs can be seen in our illustration. Gases currently being tested in the laboratory are :

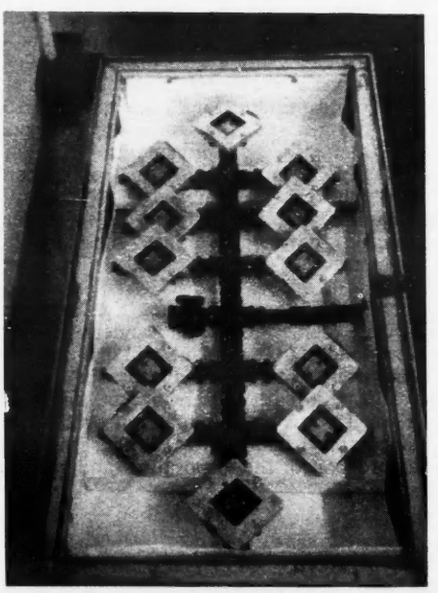
(i) Town's gas ; (ii) Humidified town's gas ; (iii) Benzolised town's gas ; (iv) Natural gas ; (v) Liquid petroleum gas ; and (vi) Natural gas at 170 deg. Fah.

In addition to testing with these six gases, gas meters and single diaphragms are tested in a low-temperature refrigerator using natural gas at a temperature of −50 deg. Fah.

(The results of low-temperature tests are particularly important on diaphragms intended for use in Canada. In that country it is customary, in many instances, to mount unprotected gas meters out of doors. Because a gas meter is a good heat exchanger there is considerable danger of meters assuming ambient temperatures ; this can mean a range of temperatures from −50 deg. Fah. in winter to 170 deg. Fah. in summer. Although a leather diaphragm can function satisfactorily in such temperatures other materials cannot. Elastometers, for instance, are normally extremely sensitive to low temperatures.)

Since the gas meter has been designed to suit the diaphragm, it is very far from an ideal instrument for assessing diaphragm performance, and special equipment has been developed to allow the linear displacement, the volumetric displacement, and the differential pressure to be observed independently instead of inferentially. Part of such an apparatus is seen in our second photograph; a diaphragm is clamped in the cylinder at the bottom, and at its centre is connected by a filament to a "windlass", the weight of the diaphragm being balanced by a weight on the other end of the filament. The windlass carries a scale of degrees which is observed to deduce the linear movement of the diaphragm. The pressure differential is measured by a manometer, inclined if necessary, or an electronic transducer. The initial measurement of swept volume is made by an instrument called the soap bubble meter, originally developed at the Gas Council Research Laboratory ; it is illustrated in our diagram. In use, the rubber bulb is squeezed to raise the soap solution within it to the mouth of the metering tube, and a film of soap blown into the tube. The flow is stopped when the film is near the top of the scale and again when it is near the bottom ; the volume displaced between readings can be measured with an accuracy of 0·05 per cent or even better. This device is of particular interest because, provided with a pair of, say, infra-red detectors, it offers the possibility of measuring rates of flow with an assurance that boundary layer errors are absent.

It appears that the Metropolitan Leather Company has been forced to the conclusion that an inherently impermeable material offers a diaphragm material fundamentally superior to leather, and various polymers are under test ; our last illustration shows a dozen small diaphragms of a shape that imposes three-dimensional distortion being subjected to rapid cycling under no other restraint than that imposed by the diaphragm itself. The polymer diaphragms are sold under the name "Melflex" ; they are available with the polymer formulated into two different elastomers, one for temperate and the other for extreme climates, and in two different constructions, homogeneous, for maximum sensitivity, and fabric-reinforced for pressure differentials exceeding 5in w.g. A standard gas meter with a homogeneous diaphragm of the M.28 compound will register a flow of 0·1 cubic foot per hour immediately after seven days storage at −40 deg. Fah.



Diaphragms undergoing pressure cycling

Apparatus for measuring linear displacement of a diaphragm ; the tubes lead to the instruments measuring volumetric displacement and pressure differential

Spelga Dam

SPELGA dam, in the Mountains of Mourne, Northern Ireland, was officially opened on June 30. It impounds a 148-acre reservoir with a capacity of 620 million gallons, and has been designed for an output of 4·43 m.g.d. to serve a population of 120,000 in an area of about 300 square miles. The dam is a gravity structure, sited near the source of the River Bann, 1120ft above sea level, and is 1000ft long. The reservoir scheme cost about £1,500,000, about a third of which was the cost of the dam. The consulting engineers were R. Ferguson and S. McIlveen of Belfast, and the contractor was John Laing and Son, Ltd.

Conveyor Belting Development Laboratory

To ensure that its belting division is fully informed of the requirements of industry and that full advantage is taken of the latest developments in materials and techniques, the Dunlop Rubber Company, Ltd., has set up a new organisation at the Speke factory near Liverpool. The organisation, based upon a recently completed industrial laboratory, is also closely associated with production control in the adjacent conveyor belting factory to ensure that specification requirements are maintained during manufacture, particularly where new or improved products or processes are concerned. The laboratory is a self-contained establishment with facilities covering all stages of production from the compounding of materials and textile preparation to the manufacture and evaluation of finished conveyor belts. It has an advantage in being able to draw upon the results of work carried out at the Dunlop research centre in Birmingham, close co-operation being maintained through a joint committee which meets regularly to discuss projects and initiate new research.

As already mentioned, the work of the conveyor belting laboratory is divided into two main sections which deal respectively with testing and development, much of the equipment used by the development section being employed to reinforce the work of process control in the factory. For testing purposes in connection with factory production control, samples are cut from every separate belt produced to undergo examination for tensile strength and elongation; impact resistance ; adhesion, tear and flame resistance ; and non-static properties. The tensile strength and elongation tests are carried out on an Amsler machine, capable of applying loads up to 30 tons, arranged to provide records of warp and weft tensile strength at break as well as elongation of samples at working load. A special machine has been developed by the firm for testing impact resistance, and on this machine a loaded pendulum delivers a predetermined impact blow on a belt sample which can be trimmed to any required degree.

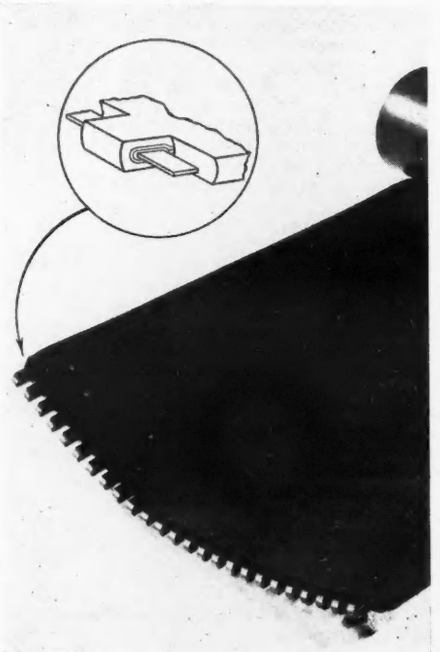
Adhesion resistance tests are made with the conventional dead load hanging weight method, but more precise measurements are made when required using a Hounsfield "Tensometer" giving a graphical record. Another "Tensometer" equipped with auxiliary devices is used to give accurate measurements of belt tear strength. To ensure that the information provided by the control tests is properly utilised, quality control charts are maintained on all important properties and trends in production can be immediately observed.

The equipment of the development section of the laboratory includes a mixing mill for preparing new compounds of rubber and p.v.c. ; a calender for evaluating the friction and topping characteristics of new compounds ; a spreader ; and a small hand-operated loom for making up experimental weaves in various fibres. To assess the power transmission and driving characteristics of transmission and conveyor belting a 25 h.p. dynamometer equipment shown in our illustration has been installed. This equipment is also used to measure coefficients of friction and for endurance tests to evaluate fatigue resistance. The driving motor on the left is carried on floating bearings and is adjustable along slideways to provide for belt loading and adjustment for different belt lengths. Through the belt under test the generator in the right background is driven, and a range of pulleys of different diameters can be fitted to the motor and generator shafts to suit the particular design of belt to be tested.

An outstanding piece of development work which has been carried out in this laboratory and which is expected to have a marked effect on future belt design and installation is the segmental belt. This design of belt is initially being used in conveyor installation and successful field trials have been completed over the past year or so. Its general construction can be seen in the photograph and diagram we reproduce. The belt is based upon a built-up mesh of steel wire or textile cord, which replaces the conventional woven textile base or carcase and provides a "castellated" form of joint claimed to have a strength and degree of cross flexibility equal to that of the main belt. The warp comprises a continuous loop of steel wires or cords bound together by rubber to form flat tapes about ¾in wide. The weft, also of wires or cords moulded in a flat strip, is about 3¼in wide and is wound at a slight angle in a continuous band over the warp tapes to form a belt of the required width.

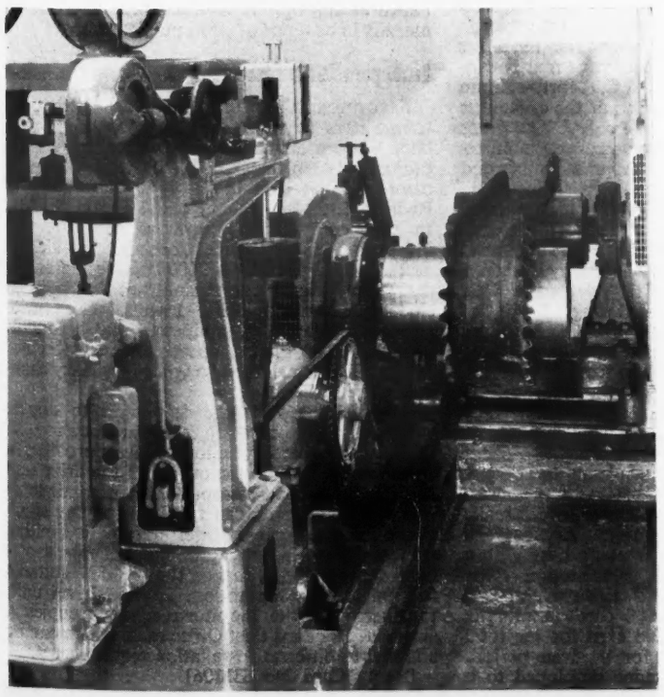
In each end of the warp loops there is inserted a flat hollow metal extension which provides a transverse slot for jointing purposes. These slotted ends of the warp structure project beyond the weft and, when the rubber body of the belt is moulded on to the mesh assembly, they provide the joint castellations. When joining two lengths of belt together the castellated ends are simply intermeshed and a flexible flat strip of steel passed through the line of slots across the full width of the belt.

These belts are being made in a number of standard lengths which are coupled together to provide the full required run of a conveyor



Segmental belt and "castellated" design of joint

installation. The form of construction enables a damaged length of belt to be quickly and easily removed and replaced without the use of tools—we are informed that in a recent test no less than four sections of belt were removed and replaced in seven minutes. Belts of this design can be made with a tensile strength of up to 30,000 lb per inch width.



Dynamometer equipment for assessing the characteristics of transmission and conveyor belts

British Standards Institution

All British Standard Specifications can be obtained from the Sales Department of the Institution at 2, Park Street, London, W.1.

HEAVY-DUTY COMPOSITE UNITS OF AIR-BREAK SWITCHES AND FUSES

No. 3185 : 1959. Price 5s. To meet requests for a standard for composite units of switches and fuses suitable for higher voltage and duties more severe than those envisaged when B.S. 2510 : 1954 ("Composite units of switches and fuses for use in industrial systems and domestic circuits") was drafted, the B.S.I. has now published a new standard dealing with composite units for industrial and power supply systems having normal current up to 800A and at a voltage not exceeding 380V to earth. The standard gives details of current and voltage ratings, construction, marking, electrical performance, and it specifies tests. An appendix gives details of temperature measurements for the tests. Fuses incorporated in the composite units are required to comply with either B.S. 88 or B.S. 3036.

ELECTRIC DISCHARGE LAMPS FOR GENERAL PURPOSES

No. 1270 : 1960. Price 5s. Revised to reflect current practice, this schedule of nineteen pages with three diagrams gives the dimensions, nominal light output, life and other relevant information in respect of electric discharge lamps. An innovation in the schedule is the incorporation of data on the electrical characteristics of lamps when operated in conjunction with suitable control gear. Among the organisations which contributed to the preparation of B.S. 1270 were : The Institution of Electrical Engineers, the Association of Supervising Electrical Engineers, and the Society of Motor Manufacturers and Traders, Ltd.

SHORTER REPORTS

Advisory Council on Research and Development

THE Minister of Power has reconstituted his Scientific Advisory Council and amended its terms of reference so as to emphasise that its advisory functions cover all aspects of research and development concerned with fuel and power from the laboratory to industrial application. The new terms of reference of the Council, which will be renamed the Advisory Council on Research and Development, are as follows: (1) To advise the Minister of Power on research and development in relation to his statutory duty of securing the effective and co-ordinated development of coal, petroleum and other sources of fuel and power in Great Britain, and of promoting economy and efficiency in the supply, distribution, use and consumption of fuel and power, whether produced in Great Britain or not. (2) To advise the Minister of new scientific and technical knowledge or applications of knowledge throughout the world, which in the opinion of the Council should be taken into account in the performance of his statutory duties. (3) To keep the whole field of fuel and power under continuous review with the object of identifying problems needing research and development and advising the Minister of these problems with a view to discussion with the industries concerned.

To ensure the co-ordination of the advice which the Minister receives on research and development matters, the Council will take over the functions of the Minister's Fuel Efficiency Advisory Committee; this committee is accordingly being wound up and the Council is being invited to appoint a standing Committee on Fuel Technology.

The members of the Advisory Council on Research and Development are as follows: chairman, Sir Alexander Fleck; deputy chairman, Captain (E) W. Gregson, R.N.R.; members, Lieut-Colonel S. J. M. Auld, Dr. C. M. Cawley, Mr. T. B. Clark, B.Sc., Sir Josiah Eccles, Mr. W. K. Hutchison, Dr. W. A. Macfarlane, Sir Harry Melville, Mr. L. Rotherham, Professor M. W. Thring, Dr. F. A. Vick, Mr. A. H. A. Wynn.

As was announced on June 28, Sir Alexander Fleck has also accepted the invitation of the Minister of Power to be chairman of the Nuclear Safety Advisory Committee, which among other things will be responsible for advising on the scientific aspects of matters relating to nuclear safety.

Poldhu Radio Site for National Trust

AT a private ceremony at Marconi House, London, on July 6, Lord Nelson of Stafford, chairman of the English Electric Group, presented to the National Trust the title deeds of some 40 acres of land at Poldhu, Cornwall, which were the site of the Poldhu radio station. The gift was accepted by Earl De La Warr, chairman of the Trust's Estates Committee. Poldhu radio was dismantled in 1937, but is commemorated by a granite column on the cliff overlooking Mounts Bay. This was the site chosen by Guglielmo Marconi in 1900 to build a wireless station of a size never before thought possible. Its purpose was secret until, on December 12, 1901, Marconi announced that signals from Poldhu had bridged the Atlantic and were being received by him at St. Johns, Newfoundland. Poldhu was in operation as a commercial wireless station for thirty-four years. In later years it was the scene of a development equally significant in the development of long-range radio communications, for it was here that the Marconi-Franklin beam system was evolved in 1924. Mr. C. S. Franklin, who joined the Marconi Company in 1899, was present at the ceremony on July 6. Another result of his research work at Poldhu was the development of coaxial cable. The granite column and some 6 acres of land along the cliff edge at Poldhu were given to the National Trust by the company in 1937. The latest gift is the remainder of the Marconi company's property in this area.

Symington's Grave in Aldgate

REFERENCE lately to the re-interment of bones disturbed, in the burial ground of St. Botolph, Aldgate, when laying drains to the crypt, is a reminder that among those buried there in unmarked graves was William Symington, who designed the engine of the first really practical steamboat. This engine—built at Carron Works under the personal supervision of Symington—was installed in the "Charlotte Dundas," the hull being constructed at Grangemouth by Alexander Hart. The engine was of 10 h.p., the double-acting cylinder being 22in diameter by 48in stroke, the drive from the piston being transmitted through a connecting-rod to a crank on the shaft of a paddle-wheel located at the stern. The trials were carried out during March, 1802, among those present being Robert Fulton. Twenty-nine years later Symington died, in poverty, in the east end of London, his burial taking place on March 22, 1831. It must be deemed as singular as it is deplorable that within the City of London or its environs there should be buried three celebrated engineers the sites of whose graves are unmarked. They are Thomas Newcomen, father of the steam engine; Richard Trevithick, father of the steam locomotive, and William Symington, father of the steamboat.

Mechanised Telephone Accounting

EXPERIMENTS and study extending over some ten years have enabled the Post Office to introduce punched card methods for the processing of accounting details from telephone call tickets. One of the first installations for this purpose came into operation last month at the Telephone Manager's Office, Cross Street, Manchester 4. The equipment of this M.T.P. (Mechanical Telephone Processing) unit was designed in collaboration between Post Office engineers at Dollis Hill and engineers of International Computers and Tabulators, Ltd., 149, Park Lane, London, W.1, and embodies a new system for converting manually-recorded information into a punched hole pattern. The machines used for this purpose are known as mark scanning punches and operate on I.C.T. forty-column card tickets which are prepared at the exchanges to record details of telephone calls. The cards carry a matrix pattern of columns and numbers which enable the calling subscriber's number and the charge for the call to be recorded by pencil marks. In passing though the mark scanning punch, a card stops for 20 milliseconds at each column position. During this stop the column is brightly illuminated and is viewed by a highly-corrected anastigmat lens of f1·9 aperture. The image so formed is projected through a series of surface-silvered mirrors, one of which oscillates at 100c/s in order to give maximum contrast range at the focal plane when a mark is being sensed. At the focal plane a photocell is located for each position where a mark may occur. The light fluctuations when a mark is being sensed therefore cause a varying current flow which is amplified electronically to energise an electromagnet. The magnets operate mechanical latches controlling the punches, which make the perforations simultaneously. Accuracy of punching is then checked for conformity with a predetermined pattern at a sensing station.

Local call cards are fed to a high-speed summariser, operating at 200 cards a minute, which produces one punched card for the total number of calls recorded for a given period. This is another I.C.T. machine developed to a Post Office specification exclusively for this work. A mechanical sorter replaces manual sorting of cards according to subscribers' numbers at a speed ten times faster than by hand, and an automatic tabulator totals and prints the statement forms on a continuous perforated card.

Metal-Sprayed Structural Steelwork

A COMMUNICATION received from the British Iron and Steel Research Association says that during the last twenty years the use of sprayed metal coatings of aluminium or zinc to protect structural steelwork has grown in importance and this method of protection is now frequently specified by consulting engineers for structures to be erected both at home and abroad. So far as is known, satisfactory results have been obtained in the majority of cases, but recently there have been several instances of premature failure of the protective scheme in important structures treated in this way. These observations have led to doubts regarding the merits of sprayed metal coatings beneath paint for the protection of structural steel. It is, therefore, important to clarify the position and lay down the conditions under which properly chosen and well applied composite protective schemes of sprayed metal coatings and paint can be relied on to protect steel satisfactorily for specified periods.

B.I.S.R.A., through its Corrosion Advice Bureau, is organising a collaborative investigation with the financial support of all who may be interested in the subject. Direct approaches have been made to the various trade associations and professional bodies concerned, but any others, including individual firms, who would like to participate are invited to write to the Secretary, Corrosion Advice Bureau, B.I.S.R.A., 140, Battersea Park Road, London, S.W.11. The object of the investigation will not be to compare a large number of painting schemes on a competitive basis but to show how good results can be achieved by following the advice given by experts based on present knowledge. To this end the test programme will be drawn up by an Advisory Research Panel, appointed at a general meeting to which all subscribers will be invited, and at which they will be free to make suggestions. The work will be carried out by the Corrosion Advice Bureau, and progress reports will be issued at appropriate intervals to subscribers six months in advance of open publication.

Independent Sideband Transmission

ELECTRICAL drive units enabling existing h.f. transmitters to work on the independent sideband system have been developed as a joint project between the G.P.O. Engineering Department and the Communications Laboratory of Redifon, Ltd., Broomhill Road, London, S.W.18. In this equipment, known as GK.191, two independent input channels, each 6 kc/s wide, are modulated by 100 and 3000 kc/s oscillators to derive an output comprising two independent sidebands centred on 3·1 Mc/s. Used with channel displacement equipment and a suitable transmitter, up to four speech channels (each of 300–3000 c/s) or thirty-two voice-frequency channels can be radiated.

A switch converts the drive unit to double sideband (a.m.) operation for emergency use. A fully-transistorised monitor receiver provides a continuous check on the output of the drive unit or of the associated transmitter. Automatic local and remote warning can be given for any significant change of carrier level; automatic limiting is incorporated in both audio input channels, and consistency of gain makes the GK.191 suitable for unattended operation. The drive unit, together with the monitor-receiver occupies a single 7ft standard Post Office rack, which can be adapted to different installation requirements.

[Reply Card No. E1106]

Productivity in Computing

SPEEDS of operation in data processing equipment exceed the best that can be expected from input/output devices in their known forms. If full advantage is to be taken of high-speed computing capacity, therefore, the operation of several devices by one computer must be considered, which involves using the computer for a number of jobs at the same time. This was the idea underlying the development of the " 1010 " Data Processing System by the Electronic Apparatus Division of Associated Electrical Industries, Ltd., by whom the system was demonstrated on July 7 at the division's new computer centre, Harper Hill, Derbyshire Road, Sale, near Manchester. The system is intended for business and industrial use, particularly in the regular revision of large quantities of stored information.

The " 1010 " computing unit illustrated can operate up to thirty-two items of peripheral equipment simultaneously, each through its own control unit. Communication between the computer store and any peripheral unit requiring to insert or extract information is effected by a high-speed data scanner, the operation of which leaves the computer free to carry out other instructions while these transfers are in progress. Idle time is minimised by an automatic " programme switch " feature for sharing computation time between the various programmes being carried out at any moment. An example of parallel programming shown at the demonstration illustrated the interleaving of two programmes in such a way that two jobs could be performed in only 5 per cent more time than would have been required to complete the long one by itself, while still leaving 28 per cent of the time available for a third job. These results are obtained by speeds of working enabling over 500,000 characters and 70,000 operations to be handled in a second. The system has been designed so that the user is not confined to a particular make of peripheral equipment but can take advantage at any time of fresh developments in this direction. Installations may be built up in stages as requirements arise.

The small size of the computing unit has been achieved by the use of transistors and printed circuit boards throughout, and compact ferrite core matrices for the working store containing the programme instructions, data, and output information for the buffer stores in each ancillary equipment control unit. A computing unit comprising the arithmetic and control unit and the control desk (as illustrated) occupies a floor space of 6ft 2in by 2ft 5½in. The working store in the arithmetic unit (2048 words, or, by addition of a plug-in unit, 4096 words) is large enough for the " 1010 " to be regarded as a single-level-storage computer for most problems. A magnetic drum store holding 8192 words is provided mainly as a store for emergency or alternative programmes, but it may be used as a second level of storage where this is considered necessary. This is housed in an additional standard cubicle measuring 2ft 1in wide by 2ft 5½in deep by 6ft 4½in high. Two cubicles of these dimensions contain the power supplies and are seen behind the operator in the illustration. It will be noted that the standard cubicle system allows flexibility in layout, which is increased by the fact that peripheral equipment can be installed in separate rooms if required.

The new computer centre at Sale organises regular courses enabling intending users to familiarise themselves with the " 1010 " system, to study programming, and to test the programmes they have written. Although several programmes can be handled simultaneously by the computer, the data scanning and programme switch facilities relieve the programmer of the task of interleaving them himself.

[Reply Card No. E1111]

Tryweryn Reservoir

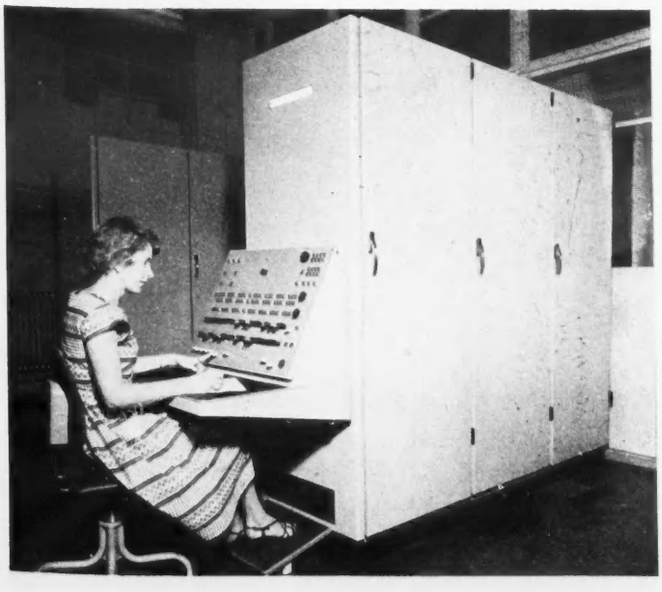
LIVERPOOL CORPORATION has accepted the tender of Tarmac Civil Engineering, Ltd., for the construction of the reservoir and dam for Liverpool's Tryweryn water supply scheme in Merionethshire, at a cost of £2,503,506. The consulting engineers for the scheme are Messrs. Binnie, Deacon and Gourley.

The dam will be a large earthen embankment, 2100ft in length and 145ft in height; the capacity of the reservoir will be 16,000,000 gallons and the dam will require about 2,750,000 cubic yards of earth, which, locally, is chiefly glacial deposit with heavy boulders.

The dam will impound the Tryweryn River which joins the River Dee at Bala about 5 miles downstream from the dam site. Water released from the reservoir will increase the flow in the River Dee in dry seasons, thus making possible the abstraction of water from the Dee at Huntngton, near Chester, where it is planned to construct an intake, together with pumping stations, a storage reservoir, treatment works, &c., and thence an aqueduct to North Merseyside.

When the reservoir is filled, the hamlet of Capel Celyn, consisting of a few cottages, a chapel and a school, together with part of the railway between Bala and Ffestiniog and the B.4391 road will be flooded. Work will start in August and will take five years to complete.

The contractor is already employed in replacing part of the B.4391, by making a new road 100ft higher up. The new road will be about 4½ miles long with a 20ft wide carriageway, and includes the construction of two bridges. One novel aspect of the main works lies in the design of the draw-off tower, where discharge will be effected by syphons; the tower was described briefly in THE ENGINEER of March 4 last.

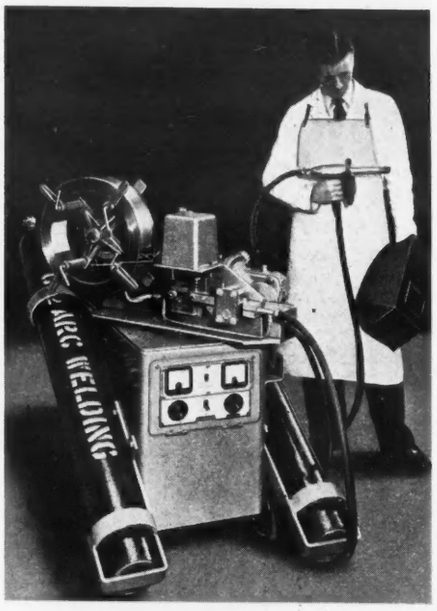


Control and arithmetic cubicles of multi-programme data processing system

Mobile CO_2 Welding Equipment

A CO_2 MANUAL welding equipment of Philips design now being marketed in this country by Research and Control Instruments, Ltd., 207, Kings Cross Road, London, W.C.1, is stated to be capable of depositing up to 12 lb of metal an hour. With this equipment, illustrated below, all positional welding is practicable using conventional d.c. power sources.

It consists of a compact three-wheeled assembly incorporating the wire reel and wire feed mechanism, two CO_2 gas cylinders with all necessary gas and electrical controls, and an associated



CO_2 welding equipment capable of depositing up to 12 lb. of metal an hour

hand-welding gun to which the welding wire, CO_2 gas and welding current are fed.

This hand-welding gun operates with welding currents up to 320A, and weighs only 3½ lb with feed cable attached. A heat barrier is incorporated in the body of the gun, and a heat-proof hand shield is fitted. The composite feed cable includes, in addition to a tube which carries the welding wire and CO_2 gas, the switch and welding current leads. A cable 12ft long is provided and the machine head rotates through 180 deg. on a turntable, permitting up to 20ft of free horizontal welding gun movement.

Mounted on the turntable are the wire coil holder and wire feed mechanism with the feed drive motor and speed controls. Three sizes of wire, 0·9mm, 1·2mm, and 1·6mm, can be used, and it is only necessary to change the gun contact tip when changing wire size. The coil holder takes 44 lb or 56 lb coils, and has an automatic friction brake. During welding the wire is fed by a solenoid-operated pressure roll and is automatically straightened by an adjustable arrangement of rollers. The wire speed is continuously variable between 6ft and 54ft per minute by means of a graduated control mounted on the gearbox.

Two standard CO_2 gas cylinders are carried in racks fixed one on each long side of the unit and a CO_2 heater with the gas regulator gauges and flow cartridge fully protected within the body. On the control panel are welding current volt and ammeters, together with on/off switch, fuses, and a red warning light, which glows if any of the interlocking safety controls operate. These safety interlocks automatically cut off the welding current and stop the wire feed if the gas supply fails. When the welding current is supplied from a motor-generator, an additional automatic control relay only allows the wire feed to operate when the generator field voltage has reached the correct value. The unit is suitable for either rectifier or motor-generator operation.

[Reply Card No. E1113]

SHORTER REPORTS *(Continued)*

Longsight Electric Locomotive Depot

THE first of the depots required for the maintenance of high-voltage a.c. locomotives and multiple-unit stock in the London Midland Region of British Railways has been opened at Longsight, Manchester. It will deal with stock in the Manchester area and will come into full operation in September this year when electrified services are introduced between Manchester and Crewe.

Two through roads, with doors at each end, serve the maintenance bay, adjacent to which is an amenities, stores and workshop block. Both roads through the bay are wired with 25kV overhead equipment, at 17ft 3in, the contact wire over No. 1 pit being erected with a maximum stagger of 18in to allow the use of a specially-designed mobile crane for removal of pantographs and auxiliaries from the locomotives. Each bay also has a standard inspection pit, 270ft long, this length being determined by the overall length of a four-car multiple-unit train. The pits are lit by recessed electric lighting fittings and have plug points for inspection lamps and other appliances.

Along each side of No. 1 pit, throughout its length, is a jacking strip 30in wide, designed to allow the use of four 20-ton electrically-operated jacks for lifting electric stock in emergencies. These jacks, seen in use in the accompanying illustration, were supplied by Matterson, Ltd., Shawclough, Rochdale, and belong to the range described in our November 27, 1959, issue, page 709.

Isolation of the 25kV equipment through the depot is by motorised switches, located on the structures at each end of the shed, which are remotely controlled from a panel situated in a central position in the maintenance bay. This panel contains push-button controls for each switch behind padlocked doors. An external over-riding emergency push button is also provided. Indicator lamps show whether the 25kV switches are open, closed, or in the earthed position, the latter being proved by auxiliary contacts on each switch in series with a 1 : 1 transformer feeding a green indicator lamp. The switches are closed by spring mechanisms wound by motors operated from the panels. Each panel controls two 25kV switches, the one which it is desired to close being selected by a rotary switch. The scheme was developed and the equipment supplied by the Electric Construction Company, Ltd., Wolverhampton, which, we understand, has since received orders for thirty similar installations.

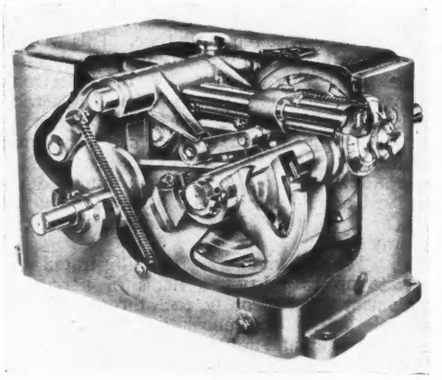
Maintenance equipment in the depot is transportable as far as possible for maximum flexibility. It includes a 6-ton mobile crane supplied by Steel's Engineering Products, Ltd., which is designed to remove roof and internal equipment from the rolling stock without it being necessary to slew the 25kV overhead equipment, which therefore only has to be isolated and earthed as described above. The crane is also available for general lifting duties and for the loading and unloading of contact wire and catenary drums. Other transportable equipment comprises an Atlas " Copco " compressor, Wakefield lubrication equipment, and battery chargers by Legg (Industries), Ltd.

Lifting a locomotive body at the depot by means of four electrically-operated jacks

Constant Torque Variable Speed Reduction Unit

A VARIABLE speed reduction unit which transmits constant torque throughout its speed range has been developed by Fairbairn, Lawson, Combe, Barbour, Ltd., of Leeds, for use in power transmission systems, machine tools, textile machines and other equipment. This unit, based upon straightforward mechanical principles, is known as the " Contorq " and is initially being made in one standard design for a constant input speed of 450 r.p.m., which gives a steplessly variable speed range of 0 to 50 r.p.m. at the output shafts. A " cut away " photograph of a typical unit is reproduced on this page and to it there can be fitted a flanged motor drive, gearing to suit particular applications or differential attachments to increase the output speed to 0 to 100 r.p.m. or a variation of 100 r.p.m. over any other range of speeds. For the given input the unit gives a constant torque output of 2520 lb in. over the speed range. Speed changes are effected by turning a knurled knob with reference to a graduated dial, and speeds can be varied with the equipment either running or stationary.

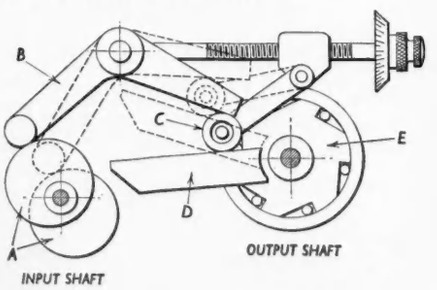
The principle of operation can be followed from the diagram below. Two single lobe cams *A* are secured on the input shaft with their lobes set at 180 deg. to each other. Rotation of these cams imparts an oscillating movement to the two levers B, the roller ends of which are held in contact with the cams by spring loading. These levers are of crank design and at their opposite ends their lower surfaces



Standard variable-speed reduction unit with casing cut away to show mechanism

register on rollers *C* which are slidable along the tops of a second set of levers *D*. The cams, through the levers *B* and the rollers *C*, thus serve to oscillate the levers *D* and, in accordance with the positive of the rollers, a greater or lesser degree of oscillation is imparted to the second set of levers. This second set of levers is coupled to free-wheel mechanisms *E* attached to the output shaft. Thus, by sliding the rollers along their path between levers *B* and *D* through their screw-operated bracket supports, the angular movement of the levers *D* is varied from zero to maximum and a proportional degree of movement is transmitted to the free-wheel mechanisms.

The angular setting of the cam lobes is such that a continuous rotary motion is imparted to the output shaft, i.e. one free wheel is imparting its turning movement whilst the other is returning to its starting position. The cams are designed to give constant angular velocity and overlap by some 50 deg. to eliminate loss of movement at the point of drive change from one free wheel to the other.



Diagrammatic arrangement of " Contorq " variable-speed reduction unit

As can be seen in the sectioned illustration, all rotating parts of the mechanism are mounted on ball and roller bearings and effective lubrication is provided from the oil bath in the bottom of the casing.

[Reply Card No. E1122]

Extended Range of High-Voltage Switch-Fuse Units

THE scope for protecting and controlling distribution transformers by high-voltage switch-fuse units has been considerably extended by the introduction of a range of powder-filled fuse links made by Line Equipment, Ltd., Bridgend, Glamorgan. With the fuse links previously available the size of transformer that could be protected by the Brush Electrical Engineering Company's HF11 switch-fuse unit was limited to about 500kVA at 11kV, but with the new fuse

links the rating has been raised to 1500kVA at 11kV.

We learn that these fuse links have been tested in accordance with B.S.2962, either at the Dutch testing station (K.E.M.A.) or at one of the testing stations of the Association of Short Circuit Testing Authorities (A.S.T.A.) in England. Certification tests were made not only at the maximum ratings specified in B.S.2962 but also at lower current ratings. The fuse links are current-limiting devices, consisting of pure silver wire or strip (depending on the current rating) wound helically on ceramic carriers, surrounded by fine silica sand and contained in a ceramic barrel fitted with copper end ferrules. A pilot fuse fed through the centre of this assembly operates a striker pin which, in turn, actuates the switch tripping mechanism.

Certified Ratings of L.E.L. Fuse Links for use in Brush Type HF11 Switch-Fuse Unit

Voltage, kV	Normal current, A	MVA
3·3	10	75
3·3	10	150
3·3	100	75
3·3	100	150
6·6	10	150
6·6	10	250
6·6	75	150
6·6	75	250
6·6	125	250
11	10	250
11	50	250
11	70	250
11	90	250

In the high-voltage switch-fuse units made by Brush Electrical Engineering Company, Ltd., Loughborough, the Line Equipment fuse links are mounted in an air-insulated fuse chamber fitted with phase separation barriers, as illustrated. Such equipments have been tested in accordance with A.S.T.A. "Rules for the Short Circuit Testing of Circuit Breakers and Automatic Switches in Combination with Electric Fuses and Fuse Links." Units equipped with fuse links rated at 50A, 70A and 90A, 250MVA, at 11kV have been successfully tested in accordance with these rules and heat runs have been carried out at the manufacturer's works to demonstrate compliance with temperature rises stipulated in B.S.2962.

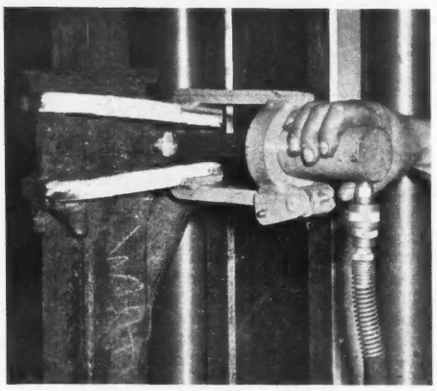
High-voltage switch-fuse unit equipped with fuse links rated at 90A, 250MVA, 11kV

The HF11 high-voltage switch-fuse unit is suitable for indoor or outdoor service and can be used singly or as part of a multi-panel switchboard, such as a ring-main unit, in conjunction with fault-making oil switches.

(Reply Card No. E1123).

N.C.B. Equipment Developments

A MECHANISM to facilitate the release of wedges used with telescopic friction props developed at the National Coal Board's Central Engineering Establishment is shown in the accompanying photograph. It consists of a small hydraulic (or pneumatic) ram which can be attached to the



Telescopic friction prop wedge release mechanism in operating position

prop stirrups by two claw arms, one fixed and the other pivoted. These arms are mounted on a collar screwed on to the ram cylinder and the end of the ram plunger is serrated to give a firm contact with the prop wedge. A flexible hose which connects the ram cylinder with a manually-operated pump is long enough to enable the operator to stand at a safe distance while the wedge is being removed to collapse the prop.

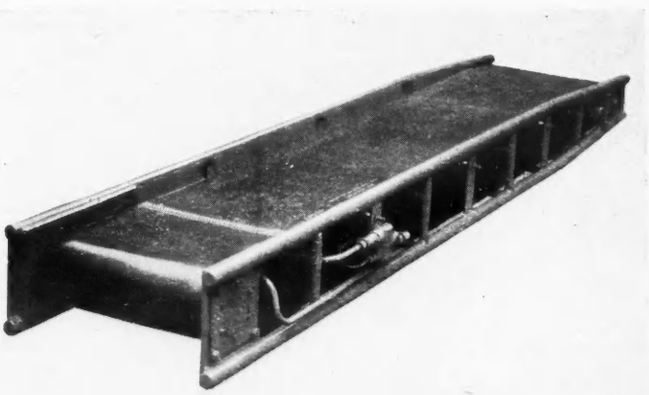
Once the unit has been fixed in position extension of the plunger when pressure is applied releases the wedge. A valve on the pump is released after the roof prop has been freed and enables the plunger to be retracted. The ram can then be removed from the prop by taking out a locking pin on the pivoted arm, which enables the arms to be removed from the prop stirrups. This mechanism can also be used to set wedges and give a constant clamping force to a prop.

Another recent development of Central Engineering Establishment is a short portable conveyor powered by a hydraulic motor. This conveyor, although originally designed for use in the stable holes of mechanised faces to cut down the wasteful operation of "casting back," has also proved sufficiently light and portable to be lifted into the pack holes where it can serve a similar purpose on the ripping shifts. As can be seen in the illustration, it consists of a light tubular frame which is 8ft long and carries an 18in wide belt. Because of the lightness of the hydraulic motor, the combined weight of the motor and driving drum is considerably less than that of an equivalent electrically-driven drum, and the overall weight of a single conveyor, including hydraulic motor, is only 270 lb.

Several of these conveyors can be driven from a single hydraulic power pack, each motor requiring 2½ gallons per minute at 600 lb to 1000 lb per square inch. The belt speed is regulated by a control valve which also ensures an even distribution of power when more than one conveyor is being driven from the same power source. Where a hydraulic power pack is already in use, as on fully mechanised faces, this equipment can also be used to drive the conveyor motor. In one such installation one of the new conveyors has given trouble-free service for about six months while operating from a 50 per cent soluble oil and water hydraulic system supplying power to the self-advancing supports on a face. This installation was in a 2ft seam, where the lightness and manœuvrability of the units proved particularly advantageous.

On longwall coal faces which are inclined at any gradient up to one in two it is the practice when using a coal cutter to flit the machine downhill and cut only on the uphill run. This technique presents a safety problem of preventing the machine from slipping, particularly while flitting operations are being carried out. To overcome this problem an automatic clamp, to be used in conjunction with a safety rope, has been designed by Mr. W. McLaren, underground shift foreman engineer at Michael Colliery. This spring-loaded and lever-operated clamp is mounted on top of the coal cutter. A safety rope, which is anchored above the machine during flitting, and above and below the machine during cutting, passes between the jaws of the clamp and is held in position by guide holes in a cover which is locked over the clamp during traversing. The clamp mechanism is so arranged that when cutting the pull on the haulage rope releases the clamp from the safety rope, allowing the machine to move. If the haulage rope breaks or slackens off for any reason, the release of tension on the clamp mechanism causes the jaws to grip the safety rope, and the machine is held where it is until tension is re-applied.

When a machine is flitting, the haulage rope is taken from the haulage drum round both idler pulleys and down the face, on the required side, to the anchor post. During flitting the strain is taken by the haulage rope and the clamp mechanism releases the safety rope, but if the machine tends to travel faster than the haulage rope can be taken in the clamp jaws lock on to the safety rope, retarding the machine until the slack in the haulage rope has been removed.



Short portable conveyor with hydraulic motor drive

The Problem of Car Parking

THE Institution of Municipal Engineers will be holding a one-day Convention on October 6, 1960, at Caxton Hall, Westminster, S.W.1, on "The Problem of Car Parking." The Institution considers that the problem of car parking is a most urgent one confronting local authorities and municipal engineers at the present time, and of fundamental importance in relation to the solution of present and future town traffic difficulties.

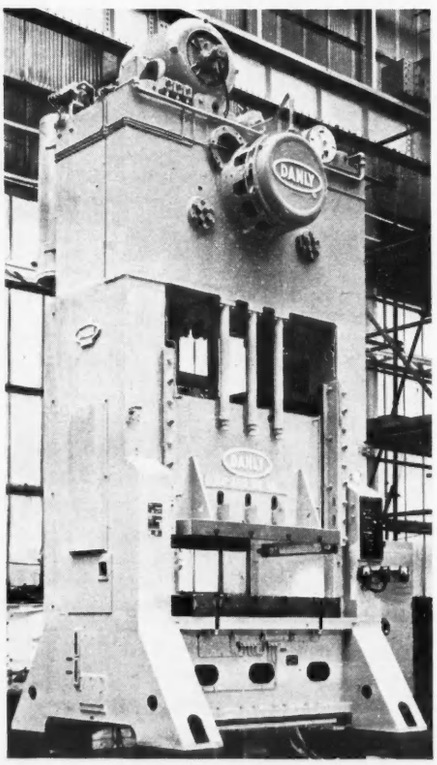
The provisional programme of the convention includes the dollowing papers: "Traffic and the Parking Problem," by Mr. J. L. Beckett, city surveyor, Leicester; "Control of Street Parking," by Mr. A. W. Hogg, city engineer, Westminster; "Roof-Top Parking and Mechanical Parking," by Mr. Granville Berry, city engineer and surveyor, Coventry; and "Parking Problems at Seaside Towns," by Mr. D. J. Howe, borough engineer and surveyor, Brighton, and Mr. E. O. Baxter.

SHORTER REPORTS *(Continued)*

Heavy-Duty Presses

THE accompanying illustration shows a typical 300-ton straight-sided, single-action press made by Danly Machine Specialities Inc., of the United States, in capacities from 100 to 2500 tons and with strokes up to 16in. This company now has offices in this country (its U.K. agent being Gaston E. Marbaix, Ltd., Darnshere House, Vicarage Crescent, London, S.W.11) and presses to its designs are being made at the Scotstoun works of Harland and Wolff, Ltd.

The presses have welded steel box frames, within the crown of which are enclosed the driving mechanism and all gearing. An air-operated clutch through which the drive is transmitted to the eccentrics on the shaft is air-cooled and has a spider friction member with solid block inserts of special friction material. If required, a two-speed clutch can be fitted; this comprises two continuous-duty, air-operated, concentrically-mounted clutches with a flywheel-



300-ton, 12in stroke, single-action press

mounted high-speed unit for return and approach movements and a low-speed unit with reduction gearing to give slow movement for the draw portion of the stroke. A spring loaded brake is held open by air pressure when the clutch is engaged and the mechanism is designed to " fail-safe " in the event of air leakage.

To eliminate bending stresses being imposed on the drive shaft by the flywheel a steel quill projecting from the press crown is designed to support the entire weight of the flywheel. This outboard mounting of the flywheel also facilitates access to all working parts of the clutch and simplifies maintenance. The drive mechanism is designed to deliver the full rated capacity of a press $\frac{1}{4}$in above the bottom of its stroke. The weight of the slide and the reciprocating parts of the press are counterbalanced by air cylinders and the air pressure can be adjusted to counter-balance also the weight of the dies. All parts of the press are automatically lubricated from a central system whilst the machine is in operation. Grouped push-button controls speed and simplify operation of the press and, if required, remote controls can readily be incorporated to suit particular applications.

The largest presses made in this range are designed for operating at seven to eighteen strokes a minute and have strokes from 16in to 32in, the smaller sizes operate at twenty-four to fifty strokes a minute over a length of 4in to 12in. The machine illustrated has a slide stroke of 12in with power adjustment over 10in. With the stroke down and the adjustment up the distance between the slide and the bed is 33in on the press.

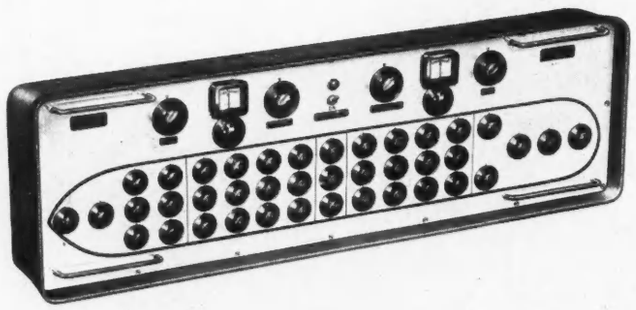
[Reply Card No. E1141]

Ship Loading Calculator

HULL damage resulting from the incorrect distribution of cargo has given rise to a demand for a rugged simple-to-operate calculator which can quickly and accurately determine the hull stress for every condition of loading. To meet this demand the Sperry Gyroscope Company, Ltd., has put on the market a calculator, of Norwegian design, under the name Sperry/Sintef loading calculator.

This is a robust electrical computer which does not use valves and is built up from standard sub-assemblies. These are fitted into a shallow cast alloy case, suitable for bulkhead mounting, the length of which depends upon the number of transverse bulkheads. The unit takes power from the ship's mains, does not require maintenance and is calibrated, as dictated by the ship's characteristics, prior to installation. Three standard sizes of calculator will be available, one suitable for cargo ships having up to twelve compartments, a second for the average tanker having thirteen to sixteen compartments and a third for a super tanker with seventeen to twenty compartments. Our illustration shows that the face plate contains an outline of the ship with a tonnage setting knob for each cargo compartment, associated with a selector switch, mean draught and shearing force setting knobs. There are similar arrangements for obtaining trim and bending moment and also a balance meter. Trim, bending moment, mean draught and maximum shear stress are obtained in sequence by setting on the cargo tonnage values for each compartment, selecting the information required and adjusting the setting knobs to obtain a zero reading on the balance meter and then reading the answer against the appropriate graduated dial.

[Reply Card No. E1142]



" Sperry Sintef " ship loading calculator

Ballast Pump

Water turbine-driven trimming pumps on board the oil tanker " Texaco Iowa," 40,950 tons dead-weight, are claimed by the maker to be the first of their kind to be installed aboard a merchant vessel. The pumps were built by De Laval Ljungström Turbine Company, Stockholm-Nacka, which also supplied her main turbines developing 16,500 s.h.p. continuous rating. The tanker was delivered by Kockums, Malmö, in the summer of 1959. Her six month survey showed the pumps to be in good condition.

The centrifugal ballast trimming pump is driven by a water turbine that is in turn driven by water delivered from a standard Butterworth fire pump. The unit is suspended submerged some 3ft from the bottom of the tank by means of its own water delivery and exhaust piping and by the discharge pipe.

It consists of a single water turbine wheel and an impeller sharing a common shaft, all enclosed in a bronze casing. All bearings are water pressure lubricated by driving water led to them from the main delivery pipe through a by-pass that has first passed through a gravity dirt trap equipped with settling tank. To obviate undue wear the bearing faces of the rotor are lined with " Ferrobestos " and those of the housing with " Stellite." Capacity is in the region of 925 gallons per minute with a rotor speed of 1500 r.p.m. The unit is designed to operate in conjunction with a Butterworth pump delivering 360 gallons per minute at 170 lb per square inch gauge. In cases where other conditions apply, adjustments can be made to the standard design. It is stated that the new pump has a capacity about double that of a normal water ejector used in conjunction with a Butterworth pump.

[Reply Card No. E1143]

Launches and Trial Trips

CLOVA, trawler ; built by John Lewis and Sons, Ltd., for Clova Fishing, Ltd.; length overall 133ft, breadth 25ft 6in, depth moulded 12ft 9in ; fish hold 6500 cubic feet, electric trawl winch ; 800 fathoms of $2\frac{3}{4}$in warp, diesel-driven trawl winch generator 121kW, two 20kW diesel-driven generators ; Polar M.44.M diesel engine 640 b.h.p. at 250 r.p.m. Trial, April 21.

MONTCALM, cargo ship ; built by William Doxford and Sons (Shipbuilders), Ltd., for Montship Lines, Ltd.; length between perpendiculars 420ft, breadth moulded 58ft 6in, depth moulded 35ft 9in, deadweight 7450 tons on open shelter deck draught ; four holds, complement of 5-ton and 10-ton derricks ; Doxford opposed-piston oil engine, five cylinders 700mm diameter by 2320mm combined stroke, $15\frac{1}{2}$ knots service speed. Trial, May 10.

NETHERLEY, trawler ; built by John Lewis and Sons, Ltd., for the Glendel Fishing Company, Ltd.; length overall 116ft, breadth 23ft, depth moulded 12ft, fish room 4700 cubic feet, 100 b.h.p. electric trawl winch, barrel capacity 500 fathoms of $2\frac{3}{4}$in warp, one trawl winch $81\frac{1}{2}$kW generator driven by 160 b.h.p. diesel engine, two 15kW diesel-driven generators ; Widdop Mark G.M.B.5 diesel engine, 550 b.h.p. at 300 r.p.m. Trial, May 10.

SCARLET IBIS, cargo and passenger ship ; built by Ferguson Brothers (Port Glasgow), Ltd., for the Government of Trinidad ; length between perpendiculars 183ft, breadth moulded 36ft 6in, depth moulded 12ft 9in, cargo 182 tons, 100 tourist-class passengers, 200 deck passengers ; speed 14 knots ; three 60kW diesel-driven generators, two Crossley Mark HRN.8 diesel engines.

INDUSTRIAL NEWS

Machine Tools

Statistics issued by the Machine Tool Trades Association giving monthly figures of deliveries, orders on hand and estimated net new orders for machine tools show that the pattern established in the closing months of 1959—a vigorous inflow of new orders, rising deliveries and growing order books—accelerated in the first four months of this year. The value of net new orders received by the industry in the first quarter increased sharply and was 145 per cent more than a year earlier. The increase in orders from abroad, 120 per cent, was less than from the home market but, nevertheless, substantial.

It is pointed out in the statement accompanying the statistics that the figures for April are estimates based on returns from firms accounting for about 75 per cent of total deliveries, whilst the figures for March incorporate information supplied quarterly by some additional firms. All figures include estimates for small firms making annual returns only.

New orders received in April, (£12,436,000) were less than in March, (£16,499,000) although still very high, states the Association. The fall in deliveries in April, £6,420,000 compared with £8,900,000 in March, can be accounted for by the normal fall in that month and the changed incidence of the Easter holiday. The order book at the end of April stood at £78,329,000, as against £72,312,000 at the end of March. Since deliveries began to expand in the second quarter of last year the growth of export deliveries has been rather faster than of deliveries to the home market. With net new orders exceeding current deliveries by a large margin orders on hand have grown rapidly. At the end of April, the statement concludes, their value was 40 per cent more than at the beginning of the year and 59 per cent more than the low point at the end of July, 1959.

The Machine Tool Trades Association has also issued attendance figures for the International Machine Tool Exhibition at Olympia, which closed last Friday, July 8. Attendances totalled 105,030 for the twelve days the show was open, compared with 102,316 for the last exhibition, held in 1956, which continued for thirteen days. Visitors from overseas numbered 10,000.

Steel Plant Expansion

Plans for the still further improvement of its iron and steelmaking capacity were announced last week by Dorman Long (Steel), Ltd. The Iron and Steel Board has given its approval to the company's proposals to install a sixth 360-ton tilting open-hearth furnace and a third 600-ton mixer at the Lackenby melting shop. It will be recalled that when the Lackenby plant was built (THE ENGINEER, August 6 and 13, 1954) provision was made for these additions. It is proposed to apply tonnage oxygen steelmaking techniques to all the open-hearth furnaces at Lackenby. Approval has also been given to the building, at the Clay Lane blast-furnace plant of the Cleveland works, of a third 27ft 6in hearth diameter furnace with a capacity of 1500 tons a day.

The estimated total capital expenditure on these latest developments is £6,819,000. Work is to begin immediately and member companies of the Dorman Long group are to be responsible for construction ; it is anticipated that the new units will be in operation by the end of next year. Their completion will increase the company's ingot steel capacity to 2,600,000 tons a year.

Employment

The Ministry of Labour says that, during May, the number of people in civil employment in Great Britain is estimated to have increased by 99,000 to a total of 23,519,000 (15,446,000 men and 8,073,000 women). Some of the increase was no doubt due to seasonal factors, as in agriculture, the distributive trades and miscellaneous services. But in most of the manufacturing groups, there were additions during May to the manpower totals. In the engineering and electrical goods group, for example, the number employed increased by 9000 to a total of 2,052,000, compared with 1,933,000 a year earlier. On the other hand, the number employed in shipbuilding and marine engineering declined by 2000 during May to a total of 255,000, compared with 267,000 a year earlier. Outside the manufacturing industries, the principal change was in building construction, in which 1,532,000 were employed, an increase of 23,000 during the month. But the number employed in mining and quarrying again fell in May, the total at the end of the month being 771,000.

In its report, the Ministry states that the number of operatives working overtime in the manufacturing industries in the week ended May 28 was 1,773,000 or 66,000 more than at the end of February. In the same week, the number of operatives on short-time working in the manufacturing industries was 31,000, which was 6000 more than at the end of April but 6000 fewer than three months earlier. The average number of hours of overtime worked in the week was eight, and the average number of hours lost by each operative on short time was ten.

Industrial Training in Operational Research

The British Iron and Steel Research Association has announced the introduction of a graduate apprenticeship scheme for specialised training in operational research. It is stated that the purpose of this scheme is to train recruits not only in the specialist techniques, but also in the practical art of applying these methods to actual industrial problems.

During the two-year course the apprentice will be regarded as a temporary member of the B.I.S.R.A. staff at a salary of £700 a year at the age of twenty-one, with an extra £25 for each year above that level. Training will consist of day-to-day experience as a member of a team engaged on actual problems in the steel industry, followed by a more formal course in techniques arranged in collaboration with the London School of Economics. The course will culminate in an examination for the Diploma in Operational Research recently instituted by the London School of Economics. The basic qualification for an apprentice is a good degree in a pure or applied science, mathematics, or statistics. It may be recalled that the Operational Research Department of B.I.S.R.A., which is sponsoring the scheme, was started in 1946, and has a wide industrial experience of operational research. It is believed that the new scheme provides an unusual opportunity for the ambitious man to acquire a first-class training in a rapidly expanding field. Further particulars, including an explanatory leaflet, can be obtained on application to B.I.S.R.A. Personnel Officer, 11, Park Lane, London, W.1.

Apprenticeship Schemes

Two new apprenticeship schemes have been announced by Pirelli, Ltd. The company says that the schemes offer opportunity to obtain a first-class grounding in engineering and production techniques for intelligent young men under the age of seventeen at the Pirelli factory, Derby Road, Burton-on-Trent. Both schemes are based on five-year apprenticeships, on completion of which the apprentices will have excellent prospects for advancement in the particular sphere in which they are interested. While they are indentured they will be given every encouragement to develop their individual talents.

A student apprenticeship scheme will be open to grammar and technical school pupils who have obtained, or expect to obtain, passes in at least five subjects at " 0 " level in the G.C.E. examinations. Two of the subjects must be mathematics and English language. The first six months will be a trial period to ensure that the apprentices will be able to settle happily into the routine of factory life. Student apprentices will be given a thorough training in machine shop, drawing-office, work study, and industrial engineering practice, and in every phase of tyre, footwear, and resilient webbing production, as well as in other aspects of factory procedure. During the fifth year they will be attached to production supervision, thus enabling them to acquire experience of management problems. A trade apprenticeship scheme will be open to suitable young men, also under the age of seventeen, who have a good educational background, are physically fit, are interested in, and show an aptitude for, the various trades involved. Again, there will be a six-month trial period enabling the young apprentices to become familiar with factory life. During this time they will begin technical courses in engineering departments, the main emphasis being on machine-shop practice and machinery maintenance. In the last year of the scheme apprentices will spend some time in the drawing-office, in the stores, and learning tool fitting. During the five years all apprentices will be able to attend courses at the local technical college without loss of pay. No premium will be involved and Pirelli, Ltd., will be responsible for all course and examination fees. Travelling expenses will be allowed in accordance with the company's general policy in this direction, and tools will be provided as required.

The schemes will be operated by the chief engineer, the personnel officer, and the training officer. They will be responsible for the selection of applicants and will act as a management committee, reviewing the progress of all apprentices at six-monthly intervals.

PERSONAL AND BUSINESS

Appointments

VISCOUNT ADDISON has been installed as president of the Institute of the Motor Industry.

MR. E. S. MILK has been appointed manager of industrial and scientific export sales, Honeywell Controls, Ltd.

CUMMINS ENGINE COMPANY, Ltd., has announced the promotion of Mr. John C. Skarratt to London office manager.

MR. T. H. COOK, M.I.E.E., has been appointed chief applications engineer of the Morgan Crucible Company, Ltd.

MR. G. A. JONES has been appointed manager of the contract supervision and installation department, Honeywell Controls, Ltd.

LONDON TRANSPORT announces that Mr. W. A. Worth has been appointed an officer of the Executive, with the title of purchasing officer.

THE HOBART MANUFACTURING COMPANY, Ltd., announces that Mr. A. W. Brenchley, sales manager, and Mr. H. R. Hetherington, A.M.I.E.E., chief engineer, have been appointed directors.

A.E.I. LAMP AND LIGHTING COMPANY, Ltd., has appointed Mr. E. V. Bowers manager of the southern region, and his offices will be at 132-135, Long Acre, London, W.C.2. Mr. Bowers has succeeded Mr. E. J. Melville who has been transferred to headquarters' staff.

THE BRISTOL AEROPLANE COMPANY, Ltd., states that, following his appointment as chairman of B.O.A.C., Sir Matthew Slattery has tendered his resignation from the boards of the Bristol Aeroplane Company, Ltd., and of its associated company, Bristol Aerojet, Ltd.

DANIEL ADAMSON AND CO., Ltd., announces that Mr. J. E. Roach has retired from the managing directorship and from the board of directors. Mr. Otto F. Reichwald has been elected a director in his place and will take up the full time appointment as managing director later in the year.

THE MOND NICKEL COMPANY, Ltd., announces that Dr. G. L. J. Bailey has relinquished his position as superintendent of Mond's development and research laboratory in Birmingham and has transferred to London to become manager of research. Mr. E. J. Bradbury has succeeded Dr. Bailey as superintendent, Birmingham.

SIR RALPH SORLEY, F.R.AeS., deputy chairman and managing director of de Havilland Propellers, Ltd., and a director of de Havilland Holdings, Ltd., retired on June 30. He has been succeeded as managing director of the Propeller Company by Mr. H. G. Sturgeon, who has been deputy managing director for the past three years.

BRISTOL AIRCRAFT, Ltd., states that following the appointment of Mr. J. B. Mackirdy, formerly deputy chief inspector, to be works manager of the company's Cardiff factory, Mr. R. A. Horrex has been appointed deputy chief inspector (aircraft) and Mr. K. L. Smith deputy chief inspector (guided weapons). Mr. R. L. Hurd has been appointed inspection administrator.

MR. W. R. FARNES, sales director of Bristol Aircraft, Ltd., has resigned from the board of directors and has been transferred to the Bristol Aeroplane Company, Ltd. He has been appointed a director of Bristol Aerojet, Ltd., in succession to Sir Matthew Slattery, and managing director of Bristol Aeroplane Plastics, Ltd.

DR. HARRY HOOKWAY has been appointed director of the United Kingdom Scientific Mission in Washington, D.C., and scientific attaché at the British Embassy there. He will succeed Mr. E. S. Hiscocks, who is returning to Britain in the autumn on completion of a three-year tour of duty to become director of the Tropical Products Institute.

CENTRAL ELECTRICITY GENERATING BOARD has announced the appointment of Mr. E. C. Shackleton, A.M.I.Mech.E., A.I.E.E., as assistant chief project engineer of the Midlands Project Group. M. Shackleton became a project engineer in the Midlands Project Group in March, 1958, and has relinquished that position to take up his present appointment.

MR. G. A. S. BARTLEY has been appointed manager of the London office of C. A. Parsons and Co., Ltd., in succession to Mr. John Packard who, following a recent illness, has asked to be relieved of some of his responsibilities. Mr. Packard will, however, remain at London office as deputy manager, a position which for a number of years past has been filled by Mr. Bartley.

ASSOCIATED ELECTRICAL INDUSTRIES, Ltd., HEAVY PLANT DIVISION, states that Mr. R. R. Auitson, M.I.Mech.E., has been appointed consultant to the division and will undertake special duties in connection with the promotion of A.E.I. business in centrifugal compressors and allied apparatus. Mr. T. E. Adams, previously chief engineer, nuclear auxiliaries department, A.E.I. turbine-generator division, has been appointed manager of the compressor engineering department, A.E.I. heavy plant division.

TURNER AND NEWALL, Ltd., has announced the following changes in the boards of certain of its subsidiary companies. Mr. N. A. Morling, who is a member of the parent board and chairman of Turner Brothers Asbestos Company, Ltd., J. W. Roberts, Ltd., and Glass Fabrics, Ltd., has been appointed to the board of Ferodo, Ltd. Mr. G. S. Sutcliffe, a member of the parent board and chairman of Ferodo, Ltd., has been appointed to the boards of Turner Brothers Asbestos Company, Ltd., J. W. Roberts, Ltd., and Glass Fabrics, Ltd.

THE CEMENTATION GROUP OF COMPANIES announces that Mr. Walkden has been appointed manager for the Far East and Australasia, responsible for the general control of contract work carried out by the Cementation Group in India, Ceylon, Australasia and Far Eastern centres but excluding New Zealand. He will relinquish his appointment as general manager India, Pakistan and Ceylon on July 28. Mr. W. J. Greig will become manager of the Indian Branch of the parent company on July 29. The Pakistan branch will be controlled by the Middle East general manager, Mr. P. Massarik, as from August 1.

THE ENGLISH ELECTRIC COMPANY, Ltd., states that Sir Gordon Radley, M.I.E.E., is now devoting part of his time to work with the English Electric Group of Companies, particularly in the development of telecommunication equipment for world markets. Sir Gordon Radley has also been elected a director of three of the Group's subsidiary companies, Marconi's Wireless Telegraph Company, Ltd., Marconi Instruments Ltd., and the English Electric Valve Company, Ltd. In addition he has been elected to the Board of the associated company, the Marconi International Marine Communication Company, Ltd.

Business Announcements

WOLF ELECTRIC TOOLS, Ltd., Pioneer Works, Hanger Lane, London, W.5, has arranged to purchase the Hanger Lane, W.5, factory premises of Arrow Electric Switches, Ltd.

MR. J. J. GRACIE, a director of the General Electric Company, Ltd., and general manager of its Witton Engineering Works, is to retire at the end of this year at his own request, after thirty-four years' service with the company.

MODERN ELECTROLYTIC PATENTS AND PROCESSES, Ltd., 39, Park Street, London, W.1., announces that its "Packaged" plants and chemicals are now available in the United Kingdom through W. Canning Ltd., and R. Cruickshank, Ltd.

B. O. MORRIS, Ltd., Morrisflex Works, Briton Road, Coventry, announces that it has formed a Wallace Division at its Coventry factory to produce cut-off machines under licence from Wallace Supplies Manufacturing Company, Chicago, U.S.A.

STANLEY COX AND CO., Ltd., 93–97, New Cavendish Street, London, W.1, has been appointed sole distributor for Kelvin Hughes operating theatre light fittings. The agreement covers sales in the United Kingdom and overseas, with the exception of Canada and U.S.A.

STONE-CHANCE, Ltd., states that its London office is to be moved early in August, together with those of its subsidiary companies Austinlite, Ltd., and Sumo Pumps, Ltd., from 28, St. James's Square, S.W.1., to Schomberg House, 82, Pall Mall, S.W.1. It will be joined at this address by its sister company Hayward Tyler, Ltd., also a member of the Stone-Platt Group.

EVERSHED AND VIGNOLES, Ltd., announces that in future it will be directly represented in the Birmingham area by a new branch office at 58, Oxford Street, Birmingham, 5, which will cover Derbyshire, Leicestershire, Shropshire, Nottinghamshire, Staffordshire, Warwickshire, and Worcestershire. Mr. E. R. O'Dell is manager of the new office.

MONSANTO CHEMICALS, LTD., Monsanto House, 10–18, Victoria Street, London, S.W.1, states that it is now able to supply development quantities of intermetallic semi-conductor materials produced by Monsanto Chemical Company, St. Louis, U.S.A. Monocrystalline and polycrystalline gallium arsenide, polycrystalline indium arsenide and polycrystalline indium phosphide are already available, and additional materials, including single and doped crystals, will be available shortly.

SIMMS MOTOR AND ELECTRONICS CORPORATION Ltd., Oak Lane, East Finchley, London, N.2. announces that the Simms Group of companies has completed negotiations to acquire the whole of the issued share capital of Dawe Instruments, Ltd., Ealing, Middlesex, and its associated manufacturing company L.M.K. Manufacturing Company, Ltd., Brentford. The board of Dawe Instruments, Ltd., has been reconstituted and with the resignation of Messrs. E. C. Kent and A. D. Wells is now as follows :—Mr. G. E. Liardet, chairman ; Mr. F. W. Dawe, managing director ; Mr. J. Ayres, Mr. M. A. Hassid and Mr. K. G. Smith.

Contracts

THE DECCA NAVIGATOR COMPANY, Ltd., has received an order to supply the fleet of the B.P. Tanker Company, Ltd. with Decca Navigator equipment, involving the provision of over 150 sets.

FOLLAND AIRCRAFT, Ltd., a member of the Hawker Siddeley Group, has received from the Ministry of Aviation an order for thirty "Gnat" tandem two-seat trainers with Bristol Siddeley "Orpheus" 100 engines of 4230 lb thrust. Five aircraft out of the original development batch of fourteen have now flown.

HEENAN AND FROUDE, Ltd., of Worcester, is to supply the International Harvester Company of Australia Pty. Ltd., with two Heenan-Dynamatic dynamometers, capable of absorbing and measuring up to 300 b.h.p. at speeds of up to 6000 r.p.m. The dynamometers will be used, in the lower speed range, for the testing of the International Harvester range of internal combustion engines.

THE EASTERN REGION OF BRITISH RAILWAYS has placed the order for three passenger ferries, for its Tilbury–Gravesend Service, with Whites Shipyard (Southampton), Ltd. Each ferry will measure 105ft length between perpendiculars, 27ft breadth moulded, 11ft 6in depth to upper deck, and draught loaded 4ft 6in. Propulsion will be by a Voith-Schneider cycloidal propeller driven by a six-cylinder Lister-Blackstone diesel engine of 337 h.p. at 750 r.p.m., giving a speed of 9 knots.

AIR PRODUCTS (GREAT BRITAIN), Ltd., announces that it is building a 380 tons per day oxygen plant at the O. Sinigaglia steel works of Cornigliano, Genoa, Italy. The oxygen plant, the first to be built for an Italian steel company, will consist of two generating units, each capable of producing 190 tons per day of oxygen, and storage for 560 tons of liquid oxygen and 420,000 cubic feet of high-pressure gaseous oxygen will also be included. The value of this order is stated to be over £1,000,000.

DANBY MACHINE SPECIALTIES INC., of Chicago and London, and the firm's U.K. Agents, Gaston E. Marbaix, Ltd., announce the receipt of a further order for twenty-seven presses valued at £1,500,000 from the Ford Motor Company, Ltd. The machines to be supplied under this order include four double-action 700-ton (inner slide tonnage) presses, and nineteen 800-ton and four 400-ton single-action presses. These Danby presses are to be built at the Scotstown works of Harland and Wolff, Ltd., to designs supplied by the Chicago head offices.

IBM UNITED KINGDOM, Ltd., has received a contract from the United Kingdom Atomic Energy Authority for a "Stretch" class computer, having a capacity of well over 1,000,000 logical operations a second. Being a solid state machine, the system can be installed in much the same floor space as the IBM 709 at present in use by the U.K.A.E.A. The new installation will have random access disc storage units capable of transferring one word every eight microseconds, six magnetic core storage units with retrieval time of 2·18 microseconds, and an extensive magnetic tape backing store. The equipment will be installed towards the end of 1961.

CONTINENTAL AFFAIRS

by Our Continental Editor

Aluminium in Rolling Stock Exhibition

No. II—(*Continued from page* 44, *July* 1)

Passenger Coaches

As far as passenger coaches are concerned, the principal data of the exhibits are summarised in Table I. One of the most interesting older exhibits was the French Railways' double-decker coach, of which forty-eight were built between 1929 and 1933, which are still in service on the Paris–Montparnasse suburban lines. The very high capacity of a total of 278 seated and standing passengers was adopted with the idea of achieving a large train capacity with platforms of limited length. An eight-coach train of 186m length carries up to 2040 passengers, while a conventional nine-coach train, with a length of 191m, can carry only 1524 passengers. The overall tare weight of the coach is 47·4 tonnes which compares not unfavourably with some of the most recent main-line rolling stock listed. The very low weight per passenger of only 170 kg, while no doubt partly due to the high passenger density adopted, could only be achieved by the employment of some 4900 kg of light alloy in place of over 13½ tons of steel. While the frame was of a special chromium-nickel steel, the exterior panelling and the roof consisted of AlCu4Mg, interior panelling of AlSiMg, and the ceiling panelling of aluminium. Light alloy was also used for heating and lighting fittings and other interior equipment, and aluminium in the form of foil was used as heat insulation. Taking into account secondary weight savings, about 12 tonnes was saved in this instance through making use of light alloys.

A very high saving of weight—69 per cent—as compared with a steel design was achieved by the experimental Swiss Michelin coach, built in 1950 by SIG, and shown in Fig. 2, which had a tare weight of 12·7 tonnes and weighed only 635 kg per metre. The figures for the body only are 3250 kg total weight, and 162·5 kg per metre. The body was carried out as a light-weight tubular girder resting on two five-axle pneumatic-tyred bogies. Use was made in its construction of extruded or folded sections of AlSiMg. The design is of interest, inasmuch as aluminium replaced steel to an unusual extent, in an effort to reduce the load upon the rubber tyres. It has now been decided, however, to replace the pneumatic bogies with ordinary two-axle bogies with steel wheelsets.

Reference has already been made to the well-known London Transport Metropolitan coaches. Low weight is of course at a particular premium on suburban lines where high accelerations are necessary to shorten transit times between the closely-spaced stations. The two most striking designs here were the experimental coaches of Hansa Waggonbau G.m.b.H., and of Waggon- und Maschinenbau G.m.b.H. (WMD), both dating from 1958–59. In the case of the Hansa coach, which has a steel and aluminium body, a weight per metre of 1010 kg is achieved while the weight per passenger is only 142 kg. The all-aluminium WMD coach (Fig. 4) does even better, achieving 950 kg per metre of run, and 133 kg per passenger. When comparing the weight per passenger figures with those for standard main-line stock the fact must of course be taken into account that the carrying capacity of suburban coaches is boosted by the large number of standing passengers, so that the weight per metre of run is more representative. It will be noted, however, that even on the latter basis the two designs score favourably over the rest, with the exception of the remarkably light-weight Swiss Michelin coach and the metre-gauge Brünig coach.

The Hansa coach has a steel chassis frame with a body and body frame of light alloy (AlMgSiF28). Some six special extruded sections are employed in the construction of the integral body, assembly being by riveting and inert gas welding (Fig. 3). The combination of steel and alloy led to a considerable lowering of the neutral axis, from approximately 1m to about 0·35m above the line of buffers, so that the body could be designed for a bending moment due to buffer impact, of only 70 metre-tonnes, as compared with the usual 200 metre-tonnes. This, together with the low specific weight of aluminium alloy, at approximately the same strength as steel, enabled a design weight of 6200 kg for the body work to be achieved. In this weight were comprised 1927 kg of aluminium. Compared with a similar all-steel structure, the saving in weight was 3·5 tonnes, i.e. 36 per cent.

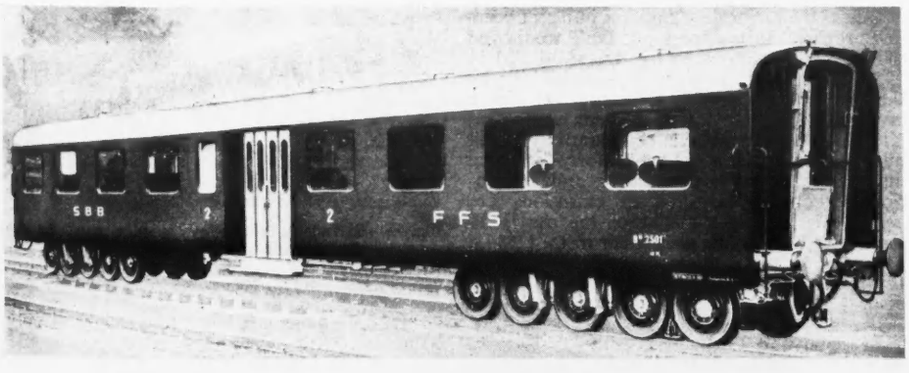


Fig. 2—Swiss lightweight coach equipped with five-axle pneumatic-tyred bogies

The connection between the steel underframe and the alloy sides was made by riveting, as the heat developed in spot welds would have weakened the alloy unduly. Rivets and washers were cadmium-plated, and contact corrosion was prevented by placing an insulating material between the steel and the alloy. Since the alloy skin is the main load-bearing number, buckling due to differential expansion between the alloy and the steel, e.g. through solar heating, had to be prevented. This was done by applying a longitudinal pretension of 3·1 tonnes to the part of the skin below the window openings during the drilling and riveting.

The WMD design, like the Hansa, was based on a tare weight of 26·4 tonnes, compared with 36·3 tonnes for the standard German long-distance express coach, and 33·5 tonnes for the ordinary express coach. The usual design requirements were maintained—200 tonnes static resistance between buffers, 50 tonnes in a plane 350mm above that of the buffers, 40 tonnes at roof level, and 50 tonnes diagonally between buffers. The vertical loading is composed of 6 to 7 tonnes structural weight of the body, 10 to 11 tonnes equipment and 15 tonnes useful load, plus the usual allowance for impact loading. Under such conditions no excessive stresses or permanent strains must arise and temporary deformation must not exceed one-thousandth of the kingpin distance (=19m).

Of the WMD coach four versions were built which differ in many important respects such as the number and arrangement of seats (compartments or open design), size of end and door sections, door design, and equipment.

Some 60 per cent by weight of the body structure consists of extruded profiles of which thirteen different special sections are employed (Fig. 5). Typical cross sections are shown in Fig. 6, (left) between kingpins, and (right) a cantilever end section. All longitudinal and transverse forces are taken up by the body for which alloys AlMgSi, AlMgMn and AlMg3 were employed, with ultimate tensile strengths of from 18 kg to 32 kg per square millimetre in the fully heat-treated condition. Underframe, side, ends, and roof were separately constructed, using for the most part inert gas are welding (" Sigma "), as well as spot welding and some riveting and bolted connections with cadmium-plated fitted bolts. Use is made of corrugated sheet for the floor, fully solution-treated after rolling. Corrugations in the roof sheets, rolled-in cold at 220mm pitch, obviate the need for purlins. Load tests on the completed coach have indicated some additional possibilities for saving weight in future versions, bringing down the weight of the body to less than 4·5 tonnes. At none of the test points did the stress exceed 300 kg per square centimetre whereas the fatigue strength of the alloy AlMgSi lies between 800 kg and 1000 kg per square centimetre, and between 500 kg and 600 kg per square centimetre for welds and riveted connections. A natural frequency of 7·2 c/s was measured with the base body and 6 c/s with the completed and loaded coach. Such a low frequency gave smooth running even with the hard suspension which was necessitated by the high passenger load.

Railcars and Trainsets

Developments in this field as illustrated at Strasbourg are outlined in Table II.

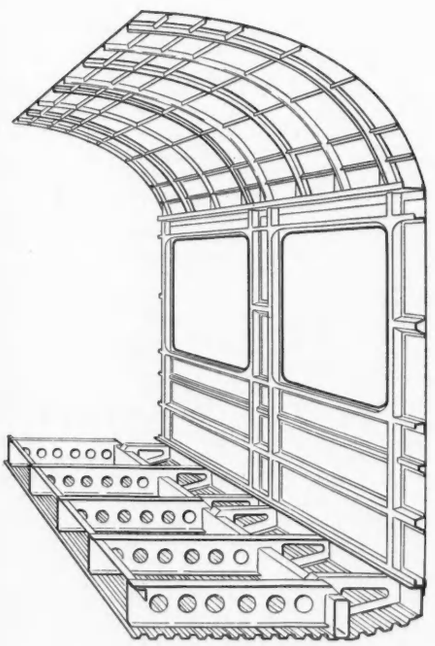
The first French railcars, the so-called " Paulines," were supplied by Entreprises Industrielles Charentaises (EIC) in 1931. These were two-axle vehicles measuring 14·8m over buffers and seating sixty passengers. From this design derived the EIC " Model 4N " bogie railcar of 1935 of which four were built, and of which an

CONTINENTAL AFFAIRS *(Continued)*

example was shown at Strasbourg. The vehicles have now been converted into trailers by the SNCF and as such weigh 22 tonnes and hold 138 passengers of whom eighty-eight are seated, plus 3 tonnes of luggage. The design has an all-AlCu4Mg self-supporting body, assembled by riveting, and using 7·4 tonnes of alloy. With the original tare of 25 tonnes (1080 kg per metre run), the saving through the use of alloy is stated to have been 14 tonnes. The original railcar carried ninety-three passengers, thus achieving a loading ratio of 270 kg per passenger.

Also of some historic interest are the two prototypes—one of which was shown—of the M.A.N. two-axle railcar of 1937. Both cars are still in service on the Nuremburg–Aschaffinburg line. In these cars there is room for thirty-seven seated and twenty-seven standing passengers, the tare weight is 12·3 tonnes, and the weight per metre run about 1 tonne. The weight per passenger is 192 kg. This was the first time on the German Railway that an aluminium riveted construction was employed. About 4 tonnes of AlMg7 and AlMg5 was used, and the saving as compared with an all-steel design was about 4 tonnes.

After the war the Waggonfabrik Uerdingen, Krefeld-Uerdingen, built a railbus for sixty-three seated and thirty-eight standing passengers.



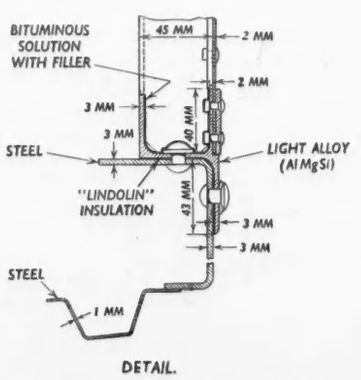


Fig. 3—Cut-away view of bodywork. The drawing shows the wide use of extruded sections ; while steel is used for the floor, the sides and roof are of light alloy. The detail shows the connection between the two metals by means of cadmium-plated steel rivets

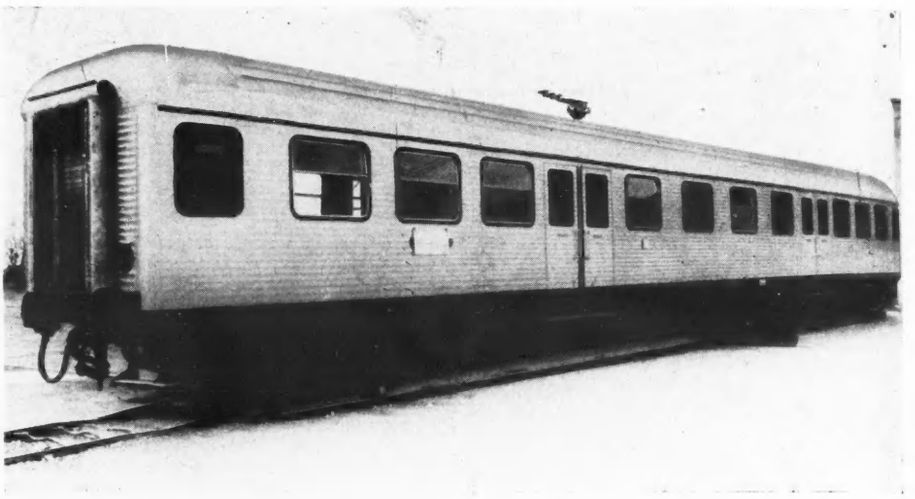


Fig. 4—Suburban prototype for 200 people. Tare weight of this integral aluminium design is 24·7 tonnes.

A total of 1900 have been built since 1950 in a number of versions, with one or two engines, and using a powered or unpowered trailer. The standard version (one engine) weighs 14 tonnes and uses about 450 kg of light alloy for the roof and roof frame and the external panelling (AlMg5 and AlMg3). The chassis and body frame is in steel. Weight per seat is 198 kg, per metre run, 0·98 tonnes. Individual vehicles have covered a total of up to 1,000,000 kilometres.

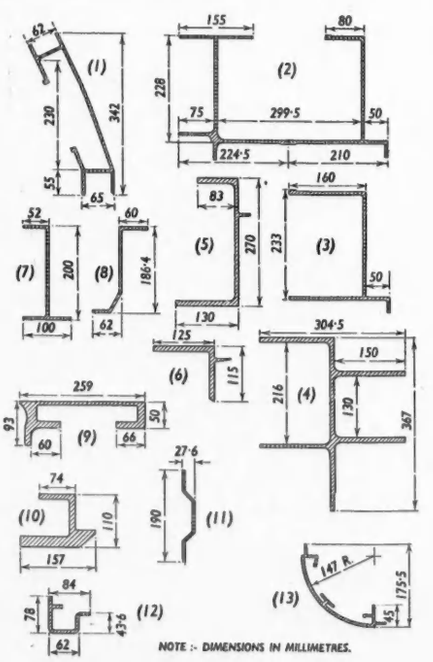
In 1954, the SNCF introduced a railcar trailer incorporating about 1000 kg of light alloy out of a total tare weight of 17·5 tonnes. These vehicles, of which 643 have been supplied to date by two makers (Decauville and Soute), are of three types, for sixty-six, seventy-seven or eighty-one passengers. The steel frame of Vierendeel girders is welded ; weight per metre run : 880 kg. Light alloy is employed for roofing and interior panels, also for fittings. It is clear that corrosion resistance and thermal insulation were the main considerations, rather than savings in weight.

Also shown was one of the Belgian two-car train sets of 1955. Since this design was first introduced, 234 vehicles have been built by a number of Belgian manufacturers. The sets, which operate on the Ostend–Liège run, have light alloy roofs built up from 1·6m-long prefabricated elements. The supporting structure consists of extrusions which are assembled by riveting in a jig. To this frame, the sheets are attached by spot-welding. The sheets are butt-welded by argon-arc welding, using as filler, metal in the form of special AlSi4 extrusions. Tare : 43·1 tonnes ; savings on "all steel" construction 1800 kg ; weight per metre, 1930 kg. Number of passengers : sixty-seven seated, eighty-seven total.

One of the major developments in recent years in European rail transport was the introduction of the "Trans-European Expresses" (TEE) in 1957. This was represented at the exhibition by the kitchen section of a German TEE dining car, built 1955–56 by Wegemann and Co., Kassel. In view of the comparatively small numbers of vehicles involved (forty-five), the multiplicity of extruded sections draws attention ; about twelve different extrusions are employed. The tare weight of the car is 24 tonnes, or 1·36 tonnes weight per metre (258 kg per metre for body only). The overall length is 17·4m. About 3·7 tonnes of alloy (AlSiMg) are used.

The most recent designs of railcars come from Switzerland and Germany. Both are electric. The Swiss design by SIG, Neuhausen, has a tare weight of 65 tonnes equivalent to 2900 kg per metre or 955 kg per passenger. Of this, 950 kg are alloy, comprising AlMgSi panelling on a steel underframe. Six of these railcars have been built.

A German railcar developed 1958–60 by Westwaggon, Cologne-Deutz, is shown in Fig. 7. It is for fast suburban traffic on the Cologne–Bonn railway (KBE). The 4800 kg body is of aluminium integral construction, with extensive use of special extruded sections. The light alloy solebars are argon-arc welded, the skin is attached to the frame members by spot-welding and riveting. Measuring 23·5m in length,



1. Cant rail. 2. Longitudinal member. 3. Longitudinal member. 4. Longitudinal member at entrance. 5. End cross member. 6. Main cross member. 7. Cross member. 8. Cross member. 9. Door jamb. 10. Frame truss. 11. Connecting profile. 12. End pillar profile. 13. Corner profile.

Fig. 5—Extruded light alloy profiles used in the coach body shown in Fig. 6

24·4m over buffers, it has a tare weight of only 30 tonnes. It seats seventy-two passengers, and holds a further seventy-eight standing passengers. The weight per metre is 1·23 tonnes (204 kg per metre for the body only). Four 75kW traction

TABLE I—*Passenger Coaches*

Item	Country	Year	Builder	Number Constructed to date	Number of Passengers (seated / standing / total)	Overall Length	Body Length	Tare Weight	Weight of Bare Body	Weight per Metre Run	Weight per Metre of Bare Body	Weight per Passenger	Weight of Light Alloy used	Weight Saving compared with All Steel Design	Weight Saving taking into account Secondary Savings	Remarks
Double Decker Suburban Coach ...	France	1929—1933	EIC	48	118 160 278	23,265mm	21,935mm	47,400 kg	28,300 kg	2,030 kg/m	1,290 kg/m	170 kg	4,900 kg	8,630 kg	12,000 kg	
Suburban Coach	Germany	1958—1959	Hansa Waggonbau	2 (expt)	100 86 186	26,400mm	26,100mm	26,400 kg	6,200 kg	1,010 kg/m	238 kg/m	142 kg	1,930 kg			
Suburban Coach	Germany	1958—1959	WMD	4 (expt)	100 86 186	26,400mm	26,100mm	24,690 kg	4 870 kg	950 kg/m	185 kg/m	133 kg				
"Michelin" Tyre Coach	Switzerland	1950	SIG	1	46 — 46	21,300mm	20,000mm	12,700 kg	3,250 kg	635 kg/m	162·5 kg/m	276 kg		69		
Standard First Class Coach	Switzerland	1957—1961	SWS, SIG, FFA	180	48 — 48	23,700mm	22,200mm	30,000 kg	9,350 kg	1,315 kg/m	410 kg/m	625 kg	1,600 kg	per cent		
Light Suburban Coach	France	1937—1939	De Dietrich, S.E.B.M.C.F., S.F.C.M.	170	94+12=106	21,830mm	20,500mm	32,000 kg	11,400 kg	1,560 kg/m	556 kg/m	300 kg	3,300 kg			
Etat "Talbot" Suburban Coach ...	France	1931—1933	Talbot, EIC, A.B.M., Carel and Fouché	380	— — 98	21,170mm	19,900mm	38,173 kg	18,000 kg	1,800 kg/m	905 kg/m	390 kg	1,500 kg	2,200 kg		
L.T.E. Surface Line Stock	United Kingdom	1949, 1959	Metropolitan-Cammell	103	— — 160	15,900mm	15,580mm	28,450 kg		1,790 kg/m		710 kg*		5,385 kg		
Brünig Second Class Coach	Switzerland	1945—1954	SIG	41	— — 68	16,380mm	15,610mm	12,300 kg	3,900 kg	788 kg/m	250 kg/m	181 kg	3,500 kg			
Chemin de Fer du Nord Articulated Train	France	1933—35, 1938	Ateliers d'Helemmes	1 set of 3 cars	274 — 538	58 000mm		75,000 kg	10,550 kg	1,290 kg/m	530 kg/m	275*, 140 kg	17,000 kg	37·5 per cent		
				1 set of 2 cars	138 — 282	40,500mm		47,000 kg	7,400 kg	1,160 kg/m	370 kg/m	240*, 125 kg	7,900 kg	45 per cent		
Chemins de Fer de l'Oust Light Carriage	France	1936	EIC	52	48 — 48†	23,263mm	21,933mm	35,500 kg		1,520 kg/m		740 kg	1,500 kg			
Coach with reclining berths (standard on FS and international trains) ...	Italy	1957 onwards				23,220mm		44,200 kg					1,885 kg			
"M2-AB" mixed class carriages (first and second class)	Belgium	1958	La Brugeoise *et al*	620	83 — 113	24,000mm	22,700mm	34,400 kg		1,520 kg/m		414 kg* 304 kg	2,500 kg			

TABLE II—*Railcars and Trainsets*

Item	Country	Year	Builder	Number Constructed to date	Number of Passengers (seated / standing / total)	Overall Length	Body Length	Tare Weight	Weight of Bare Body	Weight per Metre Run	Weight per Metre of Bare Body	Weight per Passenger	Weight of Light Alloy used	Weight Saving compared with All Steel Design	Weight Saving taking into account Secondary Savings	Remarks
TEE trains dining car/kitchen	Germany	1955—1956	Wegemann and Co.	9 (45 bodies)	— — 23	17,600mm	17,400mm	24,000 kg	4,500 kg	1,360 kg/m	258 kg/m		3,700 kg			Integral alloy construction
Two-car train set	Belgium	1955	La Brugeoise *et al*	234	67 — 87	23,265mm	22,472mm	43,100 kg		1,930 kg/m		646*, 496 kg		1,800 kg (roof only)		Alloy roof
Electric railcar for Cologne-Bonn line	Germany	1958—1960	Westwaggon	1 prototype	72 — 150	24,400mm	23,500mm	30,000 kg	4,800 kg	1,230 kg/m	204 kg/m		5,630 kg			Integral alloy construction 4-75 kW traction motors, v=120 km/h
CFF railcar	Switzerland	1959	SIG	6	68 — 68	23,700mm	22,400mm	65,000 kg	10,700 kg	2,900 kg/m	480 kg/m	955 kg	950 kg			Steel underframe alloy panelling
Two-axle Railcar trailer	Austria	1956—57	SGP	50	57 — 57	13,570mm	12,680mm	11,200 kg	8,300 kg	826 kg/m	655 kg/m	197 kg	750 kg	1,200 kg		Mixed construction
Light weight diesel railcar, motor car	United Kingdom	1954 onwards	British Railways	550 (by end of 1960)	52 — 52	18,490mm	17,700mm	29,000 kg		1,640 kg/m		558 kg	4 000 kg‡			Integral alloy construction
Light weight diesel railcar, trailer					65 — 65			21,000 kg		1,190 kg/m		323 kg				
Railcar trailer	France	1954 onwards	Decauville, Soute	643 (3 types)	66 77 81	21,192mm	19,862mm	17,500 kg		880 kg/m		216 kg	1,000 kg			Vierendeel girder welded steel frame
150 h.p. railcar	France	1953	Renault	3 (with Al panelling)	57+6	16,040mm	14,707mm	16,500 kg		1,130 kg/m		300 kg	900 kg (excl. motor)			"B" steel tubular lattice girder frame
Railbus	Germany	1950 onwards	Waggonfabrik Uerdingen	1,900	63 38 101	13,265mm	12,750mm	7,500–10,000 kg (trailer) 10,500 kg (driving trailer) 14,000 kg (1 engine) 20,300 kg (2 engines)		980 kg/m		198 kg*	450 kg			Steel underframe and body framing
M.A.N. two-axle railcar	Germany	1937	MAN	2 prototypes	37 27 64	12,500mm	11,500mm	12,300 kg		1,000 kg/m		192 kg	4,000 kg	4,008 kg		Integral aluminium (riveted)
"4N" bogie railcar	France	1935	EIC	4	93 — 93	24,410mm	23,070mm	25,000 kg	15,000 kg	1,080 kg/m	650 kg/m	270 kg				Now converted into trailers
"4N" bogie railcar (conversion into trailer)	France			4	88 50 138			22,000 kg								3,000 kg luggage capacity

*Per seated passenger † 1st Class. ‡ Structure only.

CONTINENTAL AFFAIRS *(Continued)*

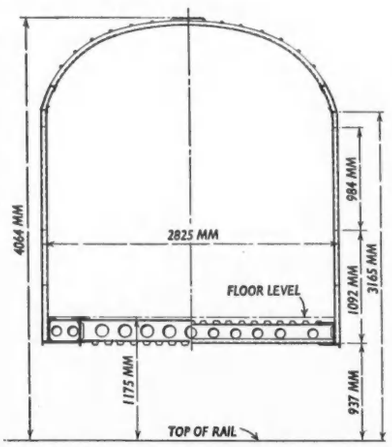


Fig. 6—Sections through aluminium coach body. (Left) Between doors. (Right) Cantilever end section. Note pressed roof corrugations which avoid the need for stringers

motors are fitted. The axle arrangement is $_0B\text{-}B_0$.

Use has been made in this design of light-alloy wheel centres. Such wheels were experimented with in Germany before the war, but wider development began only in the years since about 1948. Wheel discs must be designed to withstand fatigue failure under axial and radial loading, on which the pressures from the press-fitted tyre and axle are superimposed. The material must have a high static strength and be insensitive to notching and corrosion resistant. An AlCuMg alloy with 3·8 to 4·4 per cent Cu and 0·9 to 1·2 per cent Mg fulfils these requirements when fully heat-treated. The wheel discs are cast and after annealing are dieforged to a strongly dished shape. After machining, the wheel is anodised and lacquered. For the shrink fit between tyre and disc the lower modulus of elasticity of alloy as compared with steel is of advantage. The disc is compressed more than the tyre is expanded, thereby guaranteeing a good fit even in the case of an old and worn tyre. The good thermal conductivity of the alloy helps to remove the heat developed during braking.

Light alloy wheels have been in experimental use in Switzerland, Italy (since 1940), Britain, and France. Besides applications to passenger coaches and railcars, the wheels have been used on underground rolling stock and trams.

Goods Vehicles

During the last decade considerable headway has been made with the application of light alloys to the construction of goods vehicles (Table III). The post-war period has been characterised by an ever-increasing scale of operation and growing competition with road and inland water transport, combined with a shortage of labour necessitating far-reaching measures of rationalisation.

How the employment of light alloys can reduce the tare weight of wagons for bulk transport was well illustrated at the Strasbourg exhibition where wagons for coal, mineral, alumina, salt, cement and other materials were on show. What can be accomplished in the way of reducing tare is exemplified by the prototype, built by STEMI, of a self-discharging coal wagon (France, 1947) which has a useful capacity of 81 cubic metres and can carry up to 64·5 tonnes with a tare weight of only just over 15 tonnes giving a ratio of load : tare of 4·25. An all-steel design in this case would have weighed about 25 tonnes. About 9 tonnes of alloy were used for the body and underframe (AlMg5) which were riveted with steel and AlMg5 rivets, the AlCu4Mg bogie frame member and AlCu5 Mg Ti castings for wheel centres, buffers, axleboxes, centre castings, bogie frames, &c. This wagon has travelled more than 350,000 km, and excellent results are claimed to have been achieved with the AlMg5 panels in contact with coal which have at least three times the life of steel panels. The panels are approximately 4mm thick. Over 400 coal wagons of various designs embodying light alloy have been built in France.

Even higher load : tare ratios have been achieved by wagons for phosphates for the Moroccan railways (STEMI, SCIF, 1956), and sulphur (CIMT, 1959). In the former case a ratio of 4·7 has been attained, and up to 4·76 in the latter. The phosphate wagon has an AlMg5 body of argon-arc welded sub-assemblies riveted together. The channel section solebars of the same alloy (250mm by 100mm, 16mm thick) are fabricated by argon-arc welding, as are the bolsters. Various castings, such as buffers, axleboxes, pivots and centre bearings, are of AlCu5MgTi while the bogies themselves are AlCu4Mg forgings. Out of a total tare weight of 14 tonnes, 5·36 tonnes are light alloy. The useful volume amounts to 52·6 cubic metres, and the carrying capacity is 66 tonnes. Sixty wagons are in service with the Chemins de Fer du Maroc. They are made up into a single train of 4000 tonnes, and cover 15,000 km per year.

Many designs have been developed in France by REMAFER (formerly STEMI) and in Germany by SEAG of wagons for carrying alumina. Of the 1951 STEMI design, thirty-three wagons have been built over a period of years. The oldest of these have run nearly 1,200,000 km, and the overall tonnage transported has been 1,300,000 tonnes. These wagons are bogie designs for 20-tonne axle load, and the triple hopper containers—emptied by fluidification—can hold a total of 71 cubic metres (63·5 to 65 tonnes depending upon the version). While the earlier wagons were largely riveted, in the later series argon-arc welding was employed instead, and this and other refinements served to increase the load : tare ratio from 3·24 to 4·33. Up to 6·5 tonnes of light alloy is used per wagon, representing about 40 per cent of the total tare weight.

The most recent design in this class, of which twenty-one were built last year, has a useful capacity of 78 cubic metres equivalent to 64·3 tonnes, for a tare weight of 15·7 tonnes of which 5·5 tonnes are light alloy. The load : tare ratio is 4·1, which is the same as that of the SEAG alumina wagon. The latter has a carrying capacity of 96·5 tonnes and a tare weight of 23·5 tonnes. Its self-supporting aluminium body is assembled by riveting and inert gas welding, using AlSi5 filler rods. For sheet the alloy employed is AlMgMn, while for extrusions, which include three special sections, the alloy is AlSiMg.

Of special wagons seen at Strasbourg we may mention a French design by Frangeco of a flat wagon carrying a 35 cubic metre road trailer of 5·5 tonnes tare weight. Apart from items such as buffers which in future are to be cast in alloy, and the trailer wheel chocks, the design is a steel construction, except for the trailer panelling which consists of 150 kg of AlSiMg corrugated sheet. The stress here lies obviously in low maintenance costs, good thermal insulation, and ease of handling in the case of the chocks, of which a set of four in alloy weighs 160 kg.

Corrosion resistance and thermal insulation is the keynote in the case of the German refrigerator cars (Rathgeber, 1951) of which 650 have been built. For the interior equipment, AlMg3 and AlMgSi were used in the form of plain and corrugated sheet, as well AlMgSi forgings. The 37 to 42·3 cubic metre wagon design can carry up to 23 tonnes of meat, making the load : tare ratio approximately equal to 1·5.

Two years ago, the Swiss firm Schindler Waggon supplied the CFF with a prototype silo wagon of 48·5 cubic metres with a carrying capacity of 32·7 tonnes and a load : tare ratio of 4·5. About 3·8 tonnes of alloy were employed, in particular AlZn4Mg for the silo and underframe which were fabricated by inert gas welding. For the transport of motor-cars on the Gotthard line, the CFF this year constructed 100 flat trucks of 36·2 square metres deck area, each capable of carrying 28·5 tonnes with a tare of 10 tonnes. While the underframe is steel, the point of interest here is the neat design of the dropsides which are formed by single hollow extrusions 405mm wide and 65mm thick of AlMgSi alloy, weighing about 16 kg per metre or a total of about 500 kg. A similar idea is used in another Swiss flat wagon of 1959 in which the 450mm-high dropsides are formed by two hollow extrusions welded together along the centre.

The importance of weight savings was illustrated once again by a German prototype flat wagon for container transport, which has 6 tonnes tare for a maximum payload of 34 tonnes. Because of its 50 per cent alloy construction (AlZn4Mg sheet, AlSiMg castings), the wagon can carry five containers of 6·6 tonnes each, while the corresponding steel design can carry only four.

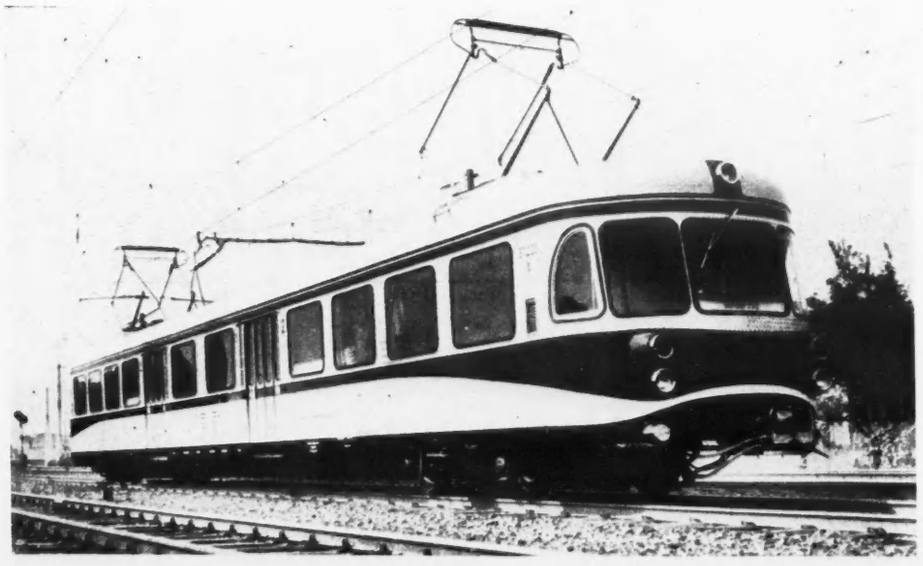


Fig. 7—German prototype motor coach built entirely of aluminium alloy. With a capacity of 150 passengers, the tare weight is only 30 tonnes, and the speed: 120 km. per hr.

TABLE III—*Goods Vehicles*

Item	Country	Year	Builder	Number Constructed to date	Useful Capacity	Useful Floor Area	Maximum Payload cubic metres	Tare Weight	Load ÷ Tare	Gauge and Track	Length over Buffers	Body Length	Under-frame Length	Body Width	Height Above Rail	Weight of Alloy Used	Remarks
Wagon with Sliding Roof and Sliding Sides	Germany	1958	SEAG	1 prototype on trials	51 (66·5m³)		27·4 (26·5) tonnes	6,000 kg	2·18 (1·96)	Normal	10 (12·5m)	8·76 (11·26m)		app. 3m	4·212m	1,100 kg	Note : alternative figures refer to two similar designs
Wagon with Aluminium Roof (modification)	Germany	1950 onwards	Several German firms and DB	25-30,000*						Normal						220 kg	
Wagon with Sliding Roof	Germany	1951	SEAG	8,500	40·5m³		28·25 tonnes	11,750 kg	2·4	Normal	10m (also 12·5 and 14·2m)	8·76m		3m	4·212m	375 kg (500 kg 580 kg)	The data given applies to the most common designs
Drop Roof Wagon (Model L7)	Switzerland	1958	Schindler	3		24m²	27·5 tonnes	12,200 kg	2·25	Normal	10·7m			3·008m	3·45m	1,160 kg	
Two-axle Wagon with Opening Sides	France	1960	CIMT, Richard	100	64·5m³		25·5 tonnes	14,500 kg		Normal (20 tonnes axle load)	12·74m			2·874m	3·984m		1 prototype with opening roof put into service in 1960
"K3" Covered Van	Switzerland	1945	CFF	8,500 (Models "J2", "K2", "K3")	51m³		20 tonnes	11,500 kg	1·7	Normal	9·83m			2·96m	3·922m	300 kg	
16-ton Mineral Wagon	United Kingdom	1955	B.R.	100	18·35m³		16 tonnes	6,300 kg	2·54	Normal	5·94m	5·03m		2·63m	2·68m	500 kg	
21-ton Coal Hopper Wagon (modification)	United Kingdom	1956	B.R.	1 (for trials)	23·9m³		21 tonnes	9,850 kg	2·13	Normal	7·47m	6·55m		2·76m	3·00m		Originally steel, lower sloping hopper plates now AlMgSiMn
Self-discharging Coal Wagon	France	1947	STEMI	1 prototype	81m³		64·5 tonnes	15,160 kg	4·25	Normal (20 tonnes axle load)	15m				3·75m	9,000 kg	Weight saving compared with all steel = 10 tonnes
Self-discharging Coal Hopper Wagon	Italy	1954	AERFER	1 prototype	25·5m³		22·9 tonnes	9,100 kg	2·52	Normal (16 tonnes axle load)	9·94m	7·39m		2·94m	3·22m	4,970 kg	
Alumina Wagons	France	1951, 1954, 1956, 1957	STEMI	33	71m³		63·5—65 tonnes	15—16·5 kg	3·24—4·33	Normal (20 tonnes axle load)	14·99m	10·446m		3·05m	4·216m	6—6·5 tonnes	
Salt Wagon (self-discharging bogie hopper wagon)	France	1956	Frange Co.	18	65m³		64 tonnes	16 kg	4·0	Normal	11·36m	9·82m		3·09m	4·00m	5,350 kg	
Two-axle Wagon for powdered material (cement, coal, cinders)	France	1955	Richard	66	47m³		31·7 tonnes	8·3 kg	3·82	Normal (20 tonnes axle load)	9·68m	8·20m		2·80m	3·78m	1,700 kg	
Bogie self-discharging Phosphate Wagon	France/ Morocco	1956	STEMI, SCIF	60	52·6m³		66 tonnes	14 kg	4·7	Normal	12m	9·722m		2·972m	4·060m	5,360 kg	
Alumina Wagon	France	1959	REMAFER (formerly STEMI)	21	78m³		64·3 tonnes	15·7 kg	4·1	Normal	14·99m	10·456m		3·05m	4·28m	5,500 kg	
Sulphur Wagon (three-axle)	France	1959	CIMT	60	41m³		48·1—49·6 tonnes	10·4—11·9 kg	4·0—4·76	Normal (20 tonnes axle load)	8·9—9·2m	7·528m		3·1m	4·04m	2,800 kg	
Alumina Wagon	Germany	1954	SEAG	2			96·5 tonnes	23·5 kg	4·1	Normal	15m	13·27m		3m	4·26m		Integral aluminium body
Wagon with Light Alloy Road/Rail Trailer	France	1960	Frange Co	50 wagons 10 light alloy trailers			23·5 tonnes	10·35 tonnes		Normal (18 tonnes axle load)	13·24m		12m			310 kg	*Trailer* : length 9·39m wheelbase 7m Tare weight 5·5 tonnes Capacity 35m³
Refrigerator Car	Germany	1951	Rathgeber	650	37—42·3m³		23 tonnes	15·1—15·5 tonnes	1·52	Normal	11·8m	10·5m		3m	4·372m	1,275 kg	
Silo Wagon	Switzerland	1958	Schindler	1	48·5m³		32·7 tonnes	7·3 tonnes	4·5	Normal	10·41m		9·17m	3·08m	4·25m	3,800 kg	
Silo Wagon	Switzerland	1957	Schindler	6	53·0m³		29·5 tonnes	10·5 tonnes	2·8	Normal	10·34m		9·1m	3·1m	4·28m	2,900 kg	
Tank Wagon	Italy	—	Montecatini	40	22·17m³		26 tonnes	9·91 tonnes	2·24	Normal (18 tonnes axle load)	8·98m	7·2m (tank)		2·1m (tank dia.)	3·7m	18,00 kg	For hydrogen peroxide, nitric acid formaldehyde
Tank Wagon	France	1957 onwards	CIMT, Fauvet-Girel	18	32·9m³		24·3 tonnes	9·7 tonnes	3·4 approx.	Normal (17 tonnes axle load)		6·216m (tank)		2·684m (tank dia)			For solvents
Flat Wagon (car transporter)	Switzerland	1960	CFF	100		36·2m²	28·5 tonnes	10·0 tonnes	2·6	Normal	13·86m		12·62m	3·02m	1·51m	500 kg	
Two-axle Dropside Flat Wagon	Switzerland	1959	CFF	260 (incl. orders)		35m²	28 tonnes	11·9 tonnes	2·35	Normal	13·98m		12·62m	2·88m		700 kg	
Flat Wagon for containers	Germany	1958	SEAG	1 on trials			34 tonnes	6 tonnes	5·7	Normal	13·25m					3,000 kg	Carries 5 containers at 6·6 tonnes (if steel, only 4 containers)

* Number of vehicles equipped.

CONTINENTAL AFFAIRS *(Continued)*

Rotterdam-Rhine Pipeline in Operation

A 24in pipeline carrying crude oil from the port of Rotterdam in the Netherlands over a total distance of some 185 miles to refineries at Gelsenkirchen, Godorf and Wesseling in Western Germany, initially at a rate of 8,500,000 tons a year, came into operation on June 27. This pipeline, which cost over £10,000,000 to build, is the first international crude oil pipeline in Western Europe. With the installation of more pumping stations, its capacity may eventually be increased to 20,000,000 tons a year.*

The new pipeline is owned and operated by N.V. Rotterdam-Rijn Pijpleiding Maatschappij (Rotterdam–Rhine Pipeline Company) ; 40 per cent of the shares of this company are held by Bataafse Petroleum Maatschappij (Royal Dutch/Shell Group), 40 per cent by Gelsenberg and Mobil Oil Handels-und Transport-Gesellschaft, and the remaining 20 per cent by the California Texas Oil Corporation. In 1958, after careful study of the transportation problems created by the increasing demand for oil in the Rhine/Ruhr area, the participating companies decided that a pipeline starting from Pernis, near Rotterdam, would be the most economic solution.

At the opening ceremony, which took place at Venlo, near the Dutch–German border, Mr. H. J. Slingenberg, joint managing director of the operating company, called the new pipeline a visible sign of the progress of European integration. He added that pipelines are expensive investments and now that they have made their appearance on the European scene—many years after North America—they are an attractive target for new forms of taxation. He warned against the temptation to impose any artificial burdens on this new form of fuel transport. " Our aim," he said, " is, and will remain, to provide energy to Europe's growing industries in the cheapest and most efficient way possible."

To build the pipeline, the company had to obtain more than 500 licences from Government, provincial, municipal and other bodies, and negotiate for right of way with 2500 landowners in Holland and Germany. The actual construction of the line involved many underwater river crossings, including the longest in Europe, 5580ft under the Holland Diep, south of Rotterdam.

From Pernis, in the Rotterdam petroleum harbour area, the pipeline runs a distance of 95 miles to Venlo, where it splits. One branch, 63½ miles long, supplies Shell's new 4,000,000 tons per year refinery at Godorf, and a refinery processing oil for Caltex at Wesseling, both situated south of Cologne ; the other branch goes to Wesel, a distance of 28 miles, where it connects up to an existing 16in pipeline leading to Gelsenberg Benzin's refinery at Gelsenkirchen. There are pumping stations at Pernis and Venlo.

O.E.E.C. Reviews Coal Situation

The gravity of the coal situation, caused by the excess of supply over demand, is emphasised in the Annual Report of the O.E.E.C. Coal Committee published under the title " The Coal Industry in Europe." The glut on the coal market, which has lasted for more than two years, is, the Committee points out, in sharp contrast with the shortage which, with a few brief exceptions, was felt from 1945 to 1957. This sometimes acute shortage and its persistence had led to the conclusion that one of the features of the energy economy of the Western European countries in the next fifteen to twenty years would be a steady increase in coal requirements.

This situation has now completely changed and is marked by an excess of supply over demand and an unprecedented accumulation of pithead stocks, which rose from 16,000,000 tons in December, 1957, to 68,000,000 tons in December, 1959. This figure in itself is enough to demonstrate the gravity of the crisis now facing the coal industry. In the two years 1958 and 1959, the coal consumption of O.E.E.C. Member countries fell by about 62,000,000 tons, or nearly 6 per cent per annum. Consumer stocks, which in general move inversely to producers' stocks, fell from 42,000,000 tons in December, 1957, to 33,000,000 tons in December, 1959.

The radical change in the coal market over the last two years naturally led the Committee to seek to define its causes. The Coal Committee believes that the present recession in coal is no doubt due to structural factors, although associated cyclical factors connected with the 1958 recession and exceptional climatic conditions have certainly helped. According to calculations made by the Secretariat, the fall of 38,000,000 tons in the demand for coal in 1958 can be explained by the recession in industrial activity (11,000,000 tons), the switch from coal to oil (12,000,000 tons), higher fuel efficiency (6,000,000 tons), the mild winter (5,000,000 tons) and exceptionally good hydro-electric conditions (4,000,000 tons). In addition, the demand for European coal was also affected by imports from countries outside the O.E.E.C. area.

In spite of great difficulties in disposing of output, the coal industry made every effort to keep up production in 1958, and output for the O.E.E.C. countries as a whole fell by 2 per cent only. In 1959, however, the rise in stocks forced producers to make a further 4·6 per cent cut in output.

In 1959, several countries took steps to try to bring production into line with demand, such as short-time working, suspension of recruitment and a policy of not replacing workers leaving the mines. This resulted in a reduction, between January, 1958, and the end of December, 1959, of 140,000 underground workers out of a registered total of 1,200,000. However, these same years (1958 and 1959) also witnessed an increase in output per underground shift in the European coal mines, amounting to 18·6 per cent in the Community and 10·8 per cent in the United Kingdom.

The Committee lists the measures taken by individual countries to palliate the coal crisis. In addition to short-time working and the suspension of recruitment already referred to, mention may be made of the following steps, although they have not been uniformly applied by all producer countries: restriction of imports from the United States, lower coal prices, additional taxes on fuel oil, closing down of certain marginal mines, and freezing of pit-head stocks. Imports from the United States fell from 44,000,000 tons in 1957 to 17,000,000 tons in 1959.

Notwithstanding these steps, and in contrast to the more favourable trend recorded in the other sectors of the economy, the coal market was still showing only slight signs of improvement at the beginning of 1960. The Coal Committee therefore considered whether previous forecasts about the future demand for coal should not be revised completely.

The Committee takes the view that in 1960 demand is likely to be stable at the present figure. It does not follow that a balance between supply and current demand will necessarily be achieved in 1960. That will depend on the outcome of the measures which the producers in the different countries are taking to adjust production, and some further increase in stocks in 1960 may therefore be unavoidable.

As regards the probable trend up to 1965, there is no reason to believe that demand for coal will fall as compared with 1959. Industrial activity is already picking up after the recent lull, and if this expansion continues, as may be hoped, the level of industrial activity in 1965 can be expected to be appreciably higher than it is now, which would entail a correspondingly higher demand for energy in one form or another.

Because of the underlying trend to the use of other fuels, in particular oil, one would expect much of the increase in energy demand to be taken up by fuels other than coal. But although the relative share of coal in the total fuel account will decline, as it has been doing for many years, the absolute demand for coal may be at least as high as now, if not higher.

If coal is produced at acceptable, i.e. competitive, prices in a market of fair competition it will continue to command large markets in the coming years. The watchword must therefore be efficient production (rather than production at any price) and concentration on the more profitable mines. This will open the way to a reorganisation of the European coal industry, which will result in the closing down of a number of marginal mines and sometimes the closing down of certain seams that have proved too difficult to work.

The danger is that production, and particularly production capacity, may be reduced more than is necessary, which in time could lead to a recurrence of coal shortage, for the closing down of a mine is an irrevocable act.

It is for this reason that the Committee considers that these actions should be reviewed periodically in the light of the latest trends. It must not, in any event, start from the assumption that the situation will get worse, but must rather be inspired by the firm determination to stop that happening by strengthening the competitive position of coal with all possible speed, without exposing workers in the industry to undue hardship.

In coal-mining, where labour accounts for about 60 per cent of production costs, short time working and the closing down of pits raise serious social problems for the workers and areas in question. So long as there are possibilities of re-employing the workers in other industries, the problem is not insoluble, but in mining areas where economic life centres exclusively on coal, resettlement may prove difficult, and it may be necessary to introduce new industries.

In conclusion, the Committee rounds off its Report with an Annex analysing the trend of coal consumption over the next few years by sector. In all probability, certain sectors which are large consumers, such as iron and steel and thermal power stations, will need more coal in the coming years. In certain other sectors, such as railways and gasworks, the marked although gradual trend away from coal will persist.

" Plastics in Industry " Exhibition at Leningrad

Following its showing in Moscow in June, I.C.I. Plastics Division's " Plastics in Industry " Exhibition opens in Leningrad on July 15. It is being held in the Exhibition Pavilion, Park of Kirov, and will be open until July 29.

Included in the exhibits are a motor-boat made from polythene, an Austin "Seven" saloon car showing the uses of I.C.I. plastics in the motor-car industry, sections of a bath room and kitchen featuring " Perspex " sanitary ware and p.v.c. flooring, large rigid p.v.c. tubing and p.v.c. conveyor belting for foodstuffs and coal.

The exhibition is designed to provide an opportunity for I.C.I. technologists to meet their opposite numbers in the Soviet plastics industry, to exchange ideas and to discuss the properties of plastics and methods of fabrication. I.C.I. is already selling polythene and p.v.c. in Russia and hopes that the exhibition will stimulate trade in these and in new plastics materials. Working demonstrations of machinery employed in the plastics industry will be given, including injection moulding and extrusion machines built by the British firm of R. H. Windsor, Ltd., The " Tetra-Pak "—a polythene-coated paper package for milk, fruit juices and other liquids—will be demonstrated in a machine capable of turning out 5400 such packages an hour.

* See also THE ENGINEER, April 3, 1959, page 550

THE AMERICAN SCENE

by Our American Editor

New Methods of Electric Power Generation

No. II—(*Concluded from page* 86, *July* 8)

The Central Research and Development Laboratories of the Westinghouse Electric Corporation are currently engaged in the investigation of four unusual methods of electric power generation, employing fuel cell, thermoelectric, thermionic and magnetohydrodynamic generating principles, respectively. While none of these methods has so far reached large-scale application in central power stations, they already are finding important uses in special fields, such as portable power generators for the armed forces and electrical energy sources for missiles and other space vehicles. Since all four of these unconventional generating techniques produce direct current, their further development necessarily requires suitable methods of conversion to alternating current.

THERE is another very important factor which determines the current flow in a thermionic converter. This phenomenon is called space charge—the mutual repulsion of electrons. An electron emerging from the cathode finds itself in the company of a swarm of other electrons, all similarly charged, from which it is repelled. This will drive most of the electrons back into the cathode before they have a chance to reach the anode. One practical way for eliminating space charge consists of introducing heavy positive ions in numbers sufficient to neutralise the charge of the electrons in the space between cathode and anode. To date, cesium ions appear to be the easiest to produce. The cesium vapour pressure is controlled by using an excess of cesium metal and keeping the coldest place in the vessel at a few hundred degrees Centigrade. Ions may be formed by contact ionisation at the hot cathode if its work function is high enough, by impact from the higher energy electrons, or by the temperature of the cesium gas between the plates. Thermionic converters of this kind have been called plasma thermocouples. The cesium collected on the anode provides a conveniently low work function.

Fig. 5 shows a typical tube containing free cesium metal. In operation, the tube is enclosed in an oven, and by keeping the device at the appropriate temperature, sufficient cesium vapour is provided to neutralise the space charge. Such a converter is capable of producing appreciable amounts of currents, sufficient to run the miniature motor or light the lamps.

The extreme temperatures required for the more efficient thermionic devices militate against their use with fossil fuels. In addition to the difficulty of achieving the required cathode temperature in the face of limited combustion temperatures and convective temperature drops, the permeability of metals to gases at high temperature poses a severe problem in maintaining for long periods of time a hermetic partition between the vacuum and the combustion spaces. It appears, therefore, that such sources as nuclear fuels and solar radiation are more favourable. Solar sources provide very high temperatures and also allow the use of a transparent vacuum window through which the radiation may be conducted while the window itself remains cool. Nuclear sources lend themselves to thermionic converters because they can provide temperatures limited only by the structural properties of the materials used. Because the anode of the device can also run at relatively high temperatures without reducing the efficiency, cascading of thermionic units with other lower-temperature converters becomes attractive. The application of thermionic converters for the commercial generation of power is most favourable when the thermionic element is used as a topping unit for a nuclear steam power plant. One is thus able to take advantage of the high temperatures available from the fuel.

A thermionic unit operating with 20 per cent conversion efficiency and topping a steam unit of 27 per cent efficiency will provide an over-all efficiency of 42 per cent, raising the output of a 50MW plant to 77MW.

In summary, it seems clear that thermionic conversion offers one possible means of obtaining efficient conversion of heat to electrical power. Whether it becomes competitive with other means will depend largely on the solution of problems concerning the properties of materials. It should be pointed out that in the past there has been no particular urge to find or produce materials having the peculiar properties demanded by the thermionic converter. The field is therefore one which is largely unexplored and in which one may expect to see advances of considerable magnitude.

Fig. 5—Experimental thermionic tube with a cesium capsule at its base for the provision of cesium vapour

Magnetohydrodynamic Generators

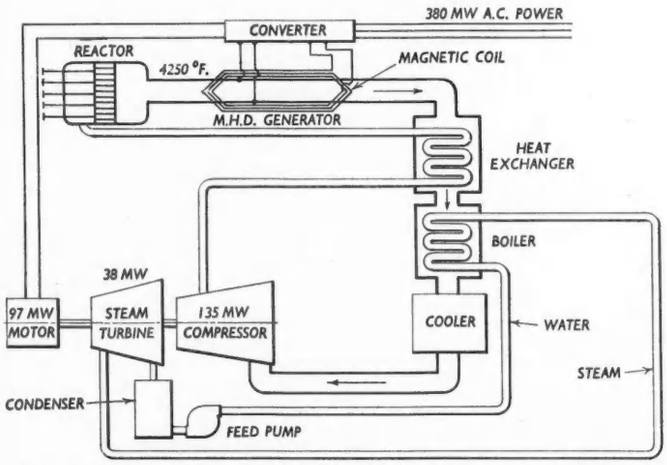
About 130 years ago, Michael Faraday discovered that a conductor moving in a magnetic field could be made to generate an electric current. This principle has traditionally been applied to produce electric power by mechanically rotating solid copper bars past energised field windings. However, Faraday's experiments showed that power can also be generated by substituting a flowing liquid metal such as mercury, or some other conducting liquid, for the copper bars. A device that uses a fluid conductor to produce an electric current is a magnetohydrodynamic (MHD) generator. The practical realisation of MHD power generation appears at the present time to depend on the use of a conducting gas. For the gas to be conducting, a certain number of free electrons must be present, together with an equal number of ions and the main body of un-ionised gas. The most direct approach to ionise a gas partially and thereby make it conducting is to heat it sufficiently. However, the temperatures involved are beyond the limits of even the most modern of materials.

When the gas is "seeded" with a certain concentration of an element such as potassium or cesium, adequate electrical conductivity can be realised at somewhat lower temperatures in the range of 4000 deg. to 5000 deg. Fah. The possibility of MHD generation, as currently conceived, hinges on the small region of overlap between the temperatures that a few materials are able to tolerate, and the temperatures which are necessary, even with seeding, to obtain adequate conductivity. In an MHD generator, hot ionised gas travels through a magnetic field which is applied at right angles to the flow, and past electrodes which are in contact with the stream of gas. Electrons in the gas are deflected by the field and, between collisions with other particles in the gas, they make their way diagonally to one of the electrodes. An electric current is produced as the electrons move from the anode, through the load, to the cathode, and back again to the gas stream.

The voltage at the terminals of an MHD generator is directly proportional to the intensity of the magnetic field, the velocity of the gas, and the distance between the electrodes. A generator will supply maximum power when the load connected to its terminals has a voltage drop equal to one-half of the circuit voltage. Near peak power, the efficiency of an MHD generator may be as low as 50 per cent, because of I^2R losses. But efficiencies in the 80 to 90 per cent range are possible when the generator is operated somewhat below maximum power. This corresponds to the efficiency of a conventional steam turbo-generator combination, which is about 80 per cent. The over-all thermal efficiency of a plant utilising an MHD generator might be as high as 60 per cent, as compared with 40 to 42 per cent for the most modern conventional steam power plants. The high efficiency of the MHD plant arises principally from the high temperature which is necessary for ionisation.

A possible cycle arrangement is shown in Fig. 6. This is a closed-cycle system in which a gas consisting of helium seeded with 1 per cent cesium is used. The plant portrayed would generate 380MW of power. It should be noted that the MHD generator puts out direct current, and that a converter is used to produce alternating current. The capital cost of this converter would be appreciable, though not prohibitive. Studies are being made for the direct MHD generation of a.c. power, and there are several

THE AMERICAN SCENE *(Continued)*



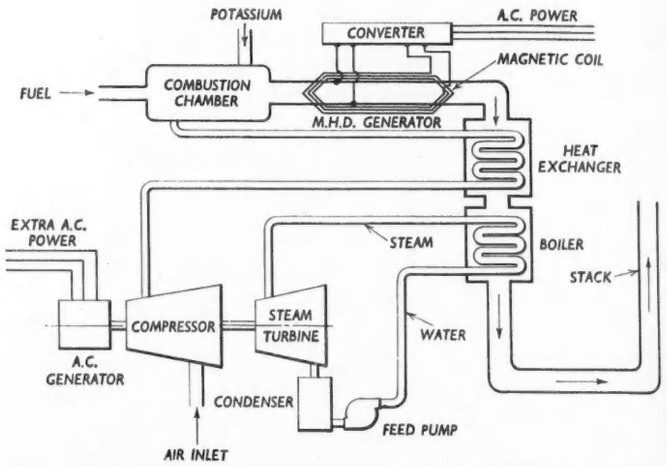


Fig. 6 —(Left) Diagram of proposed MHD generator power station with nuclear reactor heating device. Fig. 7—(Right) Diagram of proposed MHD generator power station with fossil-fuel heater supplying combustion gases to the generator

approaches to this problem that look promising. The MHD generator for this system would be 30ft to 40ft long, and it would operate in the temperature range of 4000 deg. Fah. A reactor is shown as the heating device, but the development of such a reactor would take many years. The heat exchanger, or regenerator, would also present serious development problems. The illustration also shows a boiler in which some heat is used to generate steam. This steam drives a 38MW turbine, which powers the gas compressor. It must be assisted by a motor which consumes some of the MHD generator output.

To circumvent the reactor development problems, there are two possible lines of attack : (1) the use of a combustion fired external heater, while retaining the closed loop helium system of Fig. 6, and (2) the use of an open system in which the combustion gases pass directly through the generator, as illustrated in Fig. 7. In this case, it is possible to generate a surplus of power in the steam loop so that an extra generator is present, replacing the previous d.c. motor. The temperatures of operation in the generator must now be higher, however, because of the lower mobility of electrons in combustion-product gases than in helium. Another difference is that potassium rather than cesium is used for seeding since cesium is too costly to discharge. Means would, in any case, have to be devised to avoid air pollution by the hydroxides of these elements.

The problems ahead in MHD generation development are in the general areas of physics, materials and engineering technology. Further work needs to be done to obtain more reliable data on the conduction of electricity in gases, and to provide a better understanding of the basic mechanisms of energy and momentum exchange in the MHD generator. Materials must be developed to better withstand high temperatures, sudden temperature changes, and chemical interaction with the alkali-metal seeding materials. New design approaches must be found to build durable parts of ceramic, which have conventionally been made of metal. Durable electrodes must be developed to withstand high temperatures and chemical attack, and yet they must be good conductors. To study these problems, several lines of research are being pursued at Westinghouse. First, there are basic studies of materials and their properties, and investigations in gaseous electronics. Secondly, two experimental MHD generators have been built and are in operation. One of these, illustrated in Fig. 8, is a relatively small laboratory unit ; it burns hydrogen and oxygen, seeded with potassium. The other generator project involves a machine which has, to date, produced about 2·5kW for four minutes continuously. It burns furnace oil and oxygen, with potassium soap dissolved in the oil as a seeding element. Oxygen, rather than air, was used merely to avoid the necessity of building a large air preheater.

Although MHD devices for producing short bursts of power have already been demonstrated. and may offer potential in specialised applications, such as in satellite communications systems, a generator must operate continuously for the practical generation of commercial electronic power. To date, the only American MHD generator which has been able to produce kilowatts of power over a sustained period of time is this larger machine. Furthermore, it operates on combustion products rather than on argon gas heated by an electric arc, so that it demonstrates the generation of electric power directly from a hot gas stream. The machine is shown in Fig. 9 and has an electromagnet mounted on a platform that can be raised or lowered. This magnet produces a field in the generator of 14,000 gauss. The generator section proper has a flow cross section of $1\frac{5}{8}$in by $4\frac{7}{8}$in and it is 16in long. Three pairs of graphite electrodes are mounted on opposite sides of the stream, with a distance of $4\frac{5}{8}$in between their faces. The insulating side walls are made of $1\frac{1}{4}$in thick zirconia. The flow of the combustion gas is 1·1 lb per second at the design rate, and the temperature is about 4600 deg. Fah. The velocity is about 2000 m.p.h., and the pressure of oil-soap mixture is burned with 8 lb of oxygen in a specially designed swirl combustion chamber that discharges into a mixing plenum, and then into the generator proper. Water-cooled side walls are used throughout, and zirconia lining is used everywhere except in the combustor flame tube, which is stainless steel. The 2·5kW of power corresponds to one-half of the design flow rate, or one-fourth of the power. The machine is being used to investigate generator side-wall designs, electrode materials and configurations, power distribution in the generator, chemical reactions with the seeded gas, operating characteristics of the MHD generator and electrode potential drops and potential and temperature distributions. Some reference has already been made to possible open and closed cycle and indirect heating arrangements and to direct a.c. generation. For straight-through MHD generators, various configurations are possible, including constant pressure, constant area and constant velocity designs, or various combinations of these. The indirectly-fired closed-loop system, adapted to direct a.c. generation, would seem to be one of the most promising lines of attack to follow.

D.C. to A.C. Conversion

The four unconventional methods of electric power generation that have been reviewed are

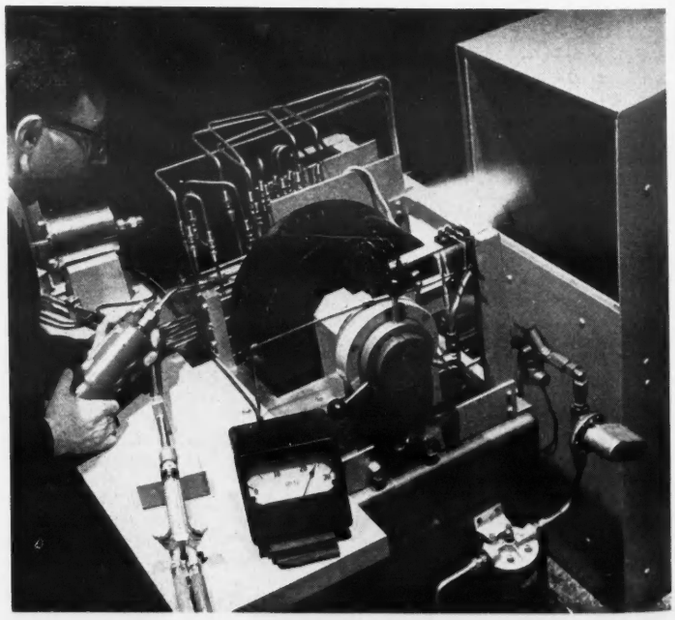


Fig. 8—Laboratory MHD generator of 1W output burning hydrogen and oxygen seeded with potassium

similar in one basic respect : all of them produce direct current. While one can use this d.c. power in some applications, the majority—particularly where large amounts of power are involved—require alternating current. Hence, there are required efficient and economical methods for converting direct current to alternating current. Several reliable and efficient inverters are available : (1) the conventional motor-generator set, (2) the mercury-arc rectifier or ignitron inverter, and (3) the newly-developed semiconductor power inverter. Both the ignitron and semiconductor inverter are basically static units, whereas the motor-generator set requires mechanical motion for operation.

The motor-generator sets now available for converting direct current to alternating current have evolved over a period of years. They are an efficient and reliable method of electric power conversion. However, since they are rotating devices, a number of disadvantages become evident. For example, there are bearings to be lubricated, carbon brushes to be replaced periodically, and commutators to be maintained.

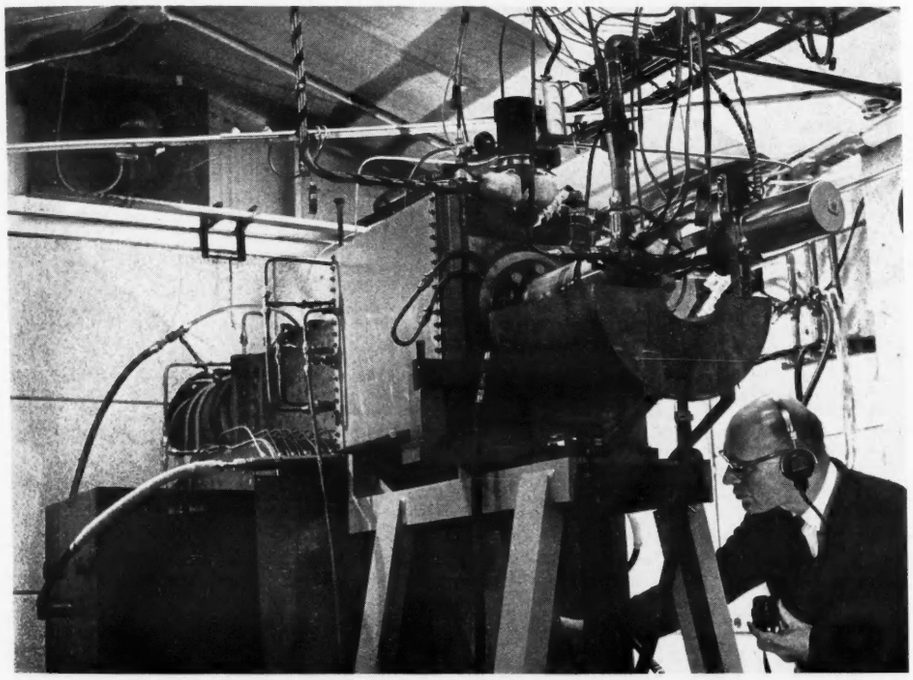


Fig. 9—Pilot MHD generator designed to produce 10kW of electric power burning an oil-soap mixture and oxygen

Of necessity, the mechanical arrangement has inertia, so that the motor-generator set must be brought up to operating conditions ; as a result, output power is not immediately available unless the machine is kept rotating constantly. However, the set has the inherent advantage of being able to withstand overload conditions for a reasonable period of time.

The ignitron inverter system is a static unit and, hence, its maintenance is less than that for most rotating systems. Since the system is essentially static, its operation is quiet. Because there are no spark-gap commutations, the operation of such a device is suitable for areas in which explosive gases might be present. The efficiency of the ignitron system is reasonably high and tends to increase as the operating voltage is increased.

The newest of the inverter systems utilises semiconductor elements. For the past several years, a rapid succession of semiconductors has been made available to perform basic electrical functions. The silicon diode and the transistor have become familiar, and more recent developments, such as the "Dynistor" and the "Trinistor" controlled rectifier, offer new possibilities for semiconductors in the power field.

The " Trinistor " rectifier consists of a silicon wafer arranged so that a control element can cause the device to go from a high impedance state to a low impedance state. Unlike the transistor, however, the control element cannot turn off the " Trinistor " switch unless the current through the device is caused to go to zero. At zero current, the control element again becomes effective and can be used to trigger the unit on whenever desired. Fundamentally, then, the " Trinistor " switch is similar to a thyratron or ignitron in its electrical characteristics. Considerable study of semiconductor units shows that the energy losses are extremely low when the devices are at minimum or maximum conduction conditions ; high losses occur only under operating conditions in which the unit is not fully turned on or off. Because of this it is extremely important that the circuitry permit the semiconductor unit to be operated in only two states—either all on or all off. It is essential that the switching time from one state to the other be made as rapid as possible for minimum dissipated energy and highest efficiency. Since the all-on, all-off type of operation is essentially the behaviour of a switch, this operation is identified as the " switching mode." All of the semiconductor power conversion equipment has been designed with this type of operation as a basic part of the circuitry. The semiconductor will perform the switching action extremely rapidly with no deterioration at a high repetition rate.

Both the transistor and the " Trinistor " controlled rectifier can be used effectively in inverters. Transistor inverters have been constructed up to the 10kW level and have performed at frequencies as high as 20 kc/s. Above the 10kW level, however, the " Trinistor " appears to be more suitable, particularly since the technical considerations indicate that extremely high powers can be obtained in single units.

An inverter requires a pair of " Trinistor " units, one of which applies the positive half cycle of the alternating current wave, and the other the negative half cycle. The inverters constructed thus far have been operated to approximately 60kW of power and as high in frequency as 20 kc/s. The " Trinistor " is relatively small and must be connected to a heat dissipating element so that the heat generated internally can be dissipated and the operating temperatures maintained at a reasonable level. Circuitry developed thus far will permit parallel or series combinations of the " Trinistor " rectifier to be operated effectively ; the output waveforms from the inverters can be made square wave or sine wave, as desired.

The basic functional element of the " Trinistor " is the specially prepared silicon wafer. The wafer itself is smaller in diameter and thinner

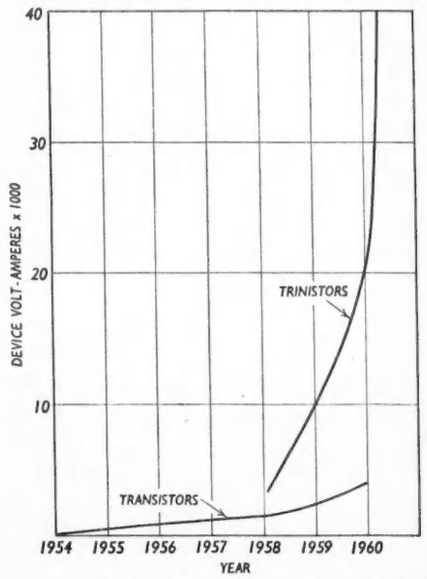


Fig. 10—Recent improvements in the power handling capabilities of semiconductor devices

than a sixpence, yet is capable of controlling 100A at 200V. Semiconductor materials are improving rapidly and, as a result, the power-handling capabilities of " Trinistors " have gone from a relatively small number of watts to the present level of 20kW in only three years. Sustained development is likely to yield even greater increases in the future, and Westinghouse expects a silicon wafer not much larger than the present unit to be capable of handling as much as 1000A at 1000V. At present, the current density in the wafer is 500A per square inch, and by 1965 it is expected to have increased to 1000A per square inch.

The power-handling capabilities of the individual semiconductor devices are illustrated in Fig. 10. The curves show that the capabilities for a single device have been increased by a factor of ten in the past two years. The static inverter is about one-half the weight of a motor-generator set for equivalent power rating. The static inverter can operate at frequencies as high as 20 kc/s, and its weight in that rating is

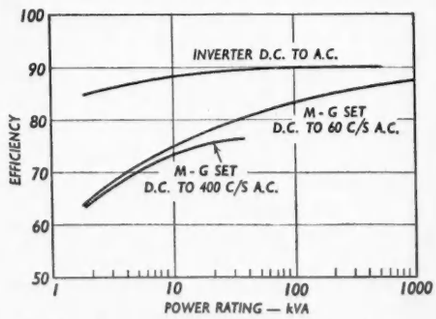


Fig. 11—Comparison of efficiencies of motor-generator sets and static inverters for power ratings up to 1000kVA

markedly below that of existing comparable motor-generator sets. However, it is expected that by the introduction of improved insulation and higher operating speeds, reductions in m.g. set size and weight may be effected in the future. Another advantage of static inverters is small volume. Since the static inverter is made up of small individual components, it can be made in almost any geometric form. This ability to vary the shape of a static inverter is of extreme importance in military applications and also will be of great importance in a variety of other applications where space is at a premium.

Perhaps the most important single factor relating to the use of semiconductor static inverters is the matter of efficiency of conversion. In Fig. 11 the efficiency of the motor-generator set at both 60 and 400 c/s is compared with the

THE AMERICAN SCENE *(Continued)*

static inverter for power ratings up to 1000kVA. Only one curve is necessary to show static inverter efficiency, because it works as well at 60 c/s as at 400 c/s. As can be seen, in the range from 10kVA to 1000kVA the static inverter is capable of extremely high efficiency—87 to 90 per cent as compared to 75 to 88 per cent for the motor-generator set. While the motor-generator set has now reached about the best

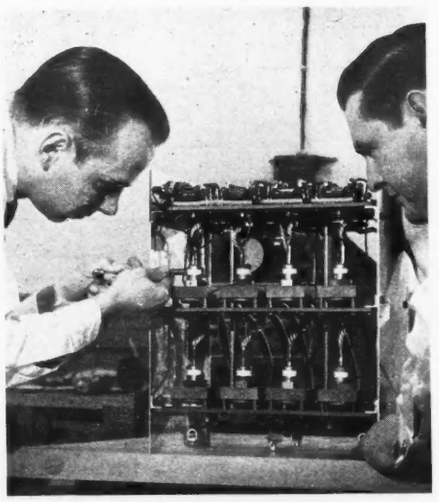


Fig. 12—Static d.c. to a.c. inverter of 15kVA capacity employing eight "Trinistor" semiconductor switching devices

efficiency that can be obtained, static inverters are still being improved rapidly. An efficiency of 95 per cent is possible as the semiconductor material and circuitry are improved.

So far, only the advantages of static inverters have been described; they also have certain disadvantages. One attribute of static power inverters is their ability to deliver power immediately when required. This is due primarily to the lack of inertial time delay, since no rotating parts are involved. However, when overloaded, the system has no inertia and little thermal energy storage and excessive voltages or currents can cause failure of the semiconductor elements. Thus it is frequently necessary to add some protective circuitry, increasing circuit complexity. Another possible disadvantage of the static inverter is that under normal conditions the unit may operate for sustained periods of time very close to the maximum allowed limits. Because of this, the designer has a tendency to allow very little factor of safety. This difficulty can be minimised, but must be kept in mind throughout all the design effort. Another problem arises from the fact that the semiconductor static inverter employs a completely new concept of electrical circuitry; operating personnel will need to be trained to understand the semiconductor apparatus. This should not be an acute problem since maintenance is expected to be extremely small, and the operating personnel in general will not have much need to provide repairs or maintenance for this apparatus.

Of major importance to the successful application of the "Trinistor" switch is the cost. For a 50MW power level, the motor-generator set at present has a cost of about 70 dollars per kilowatt and future designs may reduce this to 65 dollars. The ignitron static inverter costs about 60 dollars per kilowatt at the 600V level. In fifteen to twenty years this cost is expected to drop to about 55 dollars. The cost of the "Trinistor" static inverter is much higher than high power conventional systems at present. But it is estimated that by about 1965 the "Trinistor" inverter will be at the motor-generator set cost level, and by 1972 it should be comparable in cost to the ignitron inverter. Beyond this point, the semiconductor inverter should continue to drop in cost and should be substantially more economical than both the motor-generator sets and ignitron inverters. The cost of the "Trinistor" power inverter may eventually drop to 40 dollars per kilowatt. These figures are for inverters in the 50MW range. For many lower power applications, the semiconductor power inverter is already the most economical, and for other applications, the new inverters will soon have lower costs than conventional methods.

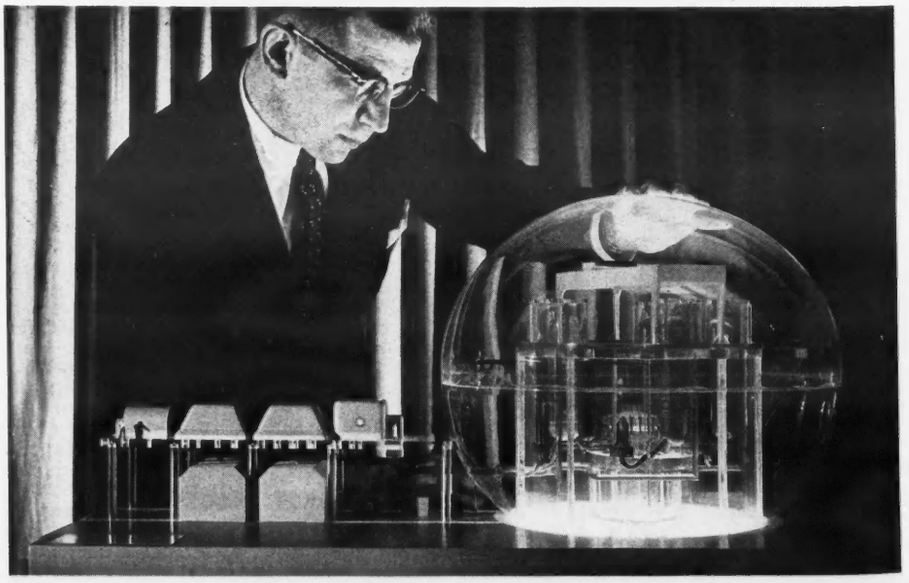
Semiconductor inverters of the type shown in Fig. 12 are now being used for a large number of military applications, and their commercial and industrial uses are just beginning to evolve. One of the more important applications is expected to come as an outgrowth of the conversion of alternating current from one frequency to another. This gives a new variable to the engineer in his design of electrical equipment. With frequency change, one can look forward to high-frequency lighting, new motor designs, new a.c. power supplies, lower cost ultrasonic generators, and new concepts in speed control for mill operation.

360MW(e) Nuclear Power Station in California

The construction of the largest American atomic electric power station may be started next year by the Southern California Edison Company. Following a recent meeting of the company's board of directors, its chairman announced that a letter of intent to negotiate contracts for the design and construction of a 360MW(e) atomic power station has been sent to the Westinghouse Electric Corporation and to the Bechtel Corporation. The proposed reactor would be the world's largest. It would be designed and built by Westinghouse who also would supply the steam and electrical equipment. The Bechtel Corporation would be the engineering constructors. The over-all plant cost is estimated at approximately 70,000,000 dollars. Based on preliminary studies, the plant would be economically competitive with conventional plants over its lifetime. According to present estimates, such a power station would require about four years to construct. The consummation of negotiations and the actual beginning of construction will depend on several factors, including the finalising of contracts, the approval of the U.S. Atomic Energy Commission and the California Public Utilities Commission, and the selection of a specific site.

The closed-cycle pressurised water reactor, which would be used in the plant, has been the subject of the most intensive research and development in America during the past decade. The interest of the utility company in this design results from the reactor's history, which indicates a high degree of reliability, safety and control. Technical details of the proposed reactor plant are given in the following table:

Power Ratings :	
Electric output, gross	360MW(e)
Electric output, net	340MW(e)
Reactor heat output	1150MW(t)
Reactor Vessel :	
Length overall	41ft
Inside diameter	12ft
Weight	340 tons
Thickness	$9\frac{3}{8}$in carbon steel + $\frac{1}{4}$in stainless steel cladding
Design pressure	2500 lb per square inch absolute
Design temperature	650 deg. Fah.
Fuel :	
Material and configuration	UO_2 pellets in rod bundles
Cladding	Zircaloy or stainless steel
Feed enrichment	2·9 to 4·0 per cent
Initial enrichment	2·1 per cent in centre zone 2·6 per cent in intermediate zone 2·9 per cent in peripheral zone
Number of assemblies per core	Fifty-two in centre zone Fifty-two in intermediate zone Fifty-two in peripheral zone
Number of of rods per assembly	182
Number of pellets per rod	155
Pellet dimensions	0·386in by 0·772in
Control Rods :	
Configuration	Cruciform
Number	Forty
Composition	Ag-In-Cd
Rod worth	16 per cent
Rod drive	Magnetic jack
Primary Circuit (five loops) :	
Operating pressure	2150 lb per square inch
Operating temperature	567 deg. Fah. average 547 deg. Fah. inlet 587 deg. Fah. outlet
Total coolant flow	75×10^6 lb per hour
Main coolant pumps	Five, each vertical, single-stage, radial-flow; bottom suction, horizontal discharge
Steam generators	Five, each vertical U-tube, integral steam drum
Length overall	45ft
Outside diameter	10ft
Design pressure, tube side/shellside	2500 lb per square inch absolute/1000 lb per square inch absolute
Tube material	Stainless steel
Shell material	Carbon steel
Weight	300,000 lb
Steam pressure, outlet	680 lb per square inch absolute
Secondary Loops :	
Steam conditions at throttle	650 lb per square inch absolute/495 deg. Fah. dry and saturated
Steam flow to turbine	4·5 million lb per hour
Turbine rated capacity	360MW(e) at 1·5in Hg back pressure
Turbine design	Tandem compound, quadruple flow; 1800 r.p.m.



Scale model of proposed 360MW(e) atomic power station in California

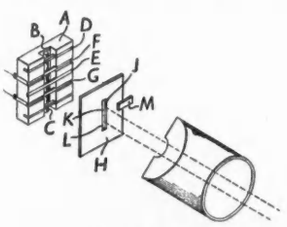
BRITISH PATENT SPECIFICATIONS

The dates printed are those of application and publication on completion. Copies of specifications may be obtained at the Patent Office Sales Branch, Southampton Buildings, Chancery Lane, W.C.2, 3s. 6d. each

ELECTRONICS

837,102. November 25, 1955.—ELECTRON GUNS, Sylvania Electric Products, Inc., 100, West 10th Street, Wilmington, Delaware, United States of America.

It has been found possible by means described in this specification greatly to simplify the construction of multi-beam cathode ray tubes by using a single electron beam source and a beam splitting member separated from but in intimate association with the source in such manner that any desired number of electron beams can be derived. The gun structure shown in the drawing includes a ceramic rectangular block *A*. The block is provided with a rectangular channel *B* in which is mounted a conventional cathode *C* having an electron emissive plane or cylindrical surface which faces the tube screen. The block is also provided with grooves which contain cathode support and spacing members *D*. Additional grooves in the block contain a beam splitting wire member *E* and two beam intensity control elements *F* and *G*. Secured to the top block surface is a slotted metal electrode *H* provided with a rectangular slot *J* having its long dimension extending parallel to the axis of the cathode. The slot is so positioned with respect to the member *E* and control elements *F* and *G* that the member spans the width of the slot and



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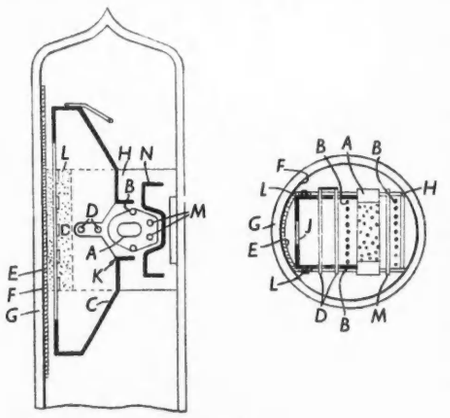
divides it into two vertically displaced sections *K* and *L*. Each of the control elements *F* and *G* also spans the width of the slot, one wire being positioned in each slot section. The slotted electrode *H* and member *E* are maintained in electrical contact with each other and form an equipotential surface ; the control elements *F* and *G* are insulated from the slotted electrode and member. A tab connection *M* is connected to the slotted member in conventional manner. When the entire tube is assembled and rendered operative, the electron stream generated by the cathode passes through the slot. The electrons passing through the slot will tend to pass around member *E*, thus forming two electron sub-streams or beams passing through slot sections *K* and *L*, respectively. When voltages are supplied to the control elements, each beam is intensity modulated in conventional manner ; these beams are isolated from each other. By omitting one or both control elements, each or both beams can be generated substantially free of intensity modulation. By increasing the number of beam splitting members, the slot can be divided into a larger number of sub-sections and the number of beams can be correspondingly increased. Additional control elements can be used to control the intensity of these additional beams.—*June* 9, 1960.

838,078, August 24, 1956.—THERMOMETER TYPE VOLTAGE INDICATOR TUBE, Standard Telephones and Cables, Ltd., Connaught House, 63, Aldwych, London, W.C.2.

This invention relates to thermometer-type voltage indicator tubes, in which in particular the longitudinal expansion of a fluorescent image is changed by the voltage to be indicated. The width of the fluorescent image is to remain constant. In order to produce a tube which gives a clearly visible indication and has a high sensitivity, the present invention suggests a thermometer-type indicator tube in which, when there is a change of voltage on the control electrode, the length and mutual spacing of two luminous strips are so changed that, as the deflecting voltage decreases with respect to the cathode potential, the length of the luminous strips decreases and the distance between them becomes greater in a direction parallel to the longitudinal axis of the envelope tube. By the reciprocal movement of the two luminous strips a good sensitivity of indication is obtained. The indicator system shown in the drawings includes a cathode *A*, a grid *B*, a diaphragm *C*, the deflecting electrode *D*, and a fluorescent layer *E* which is applied to the optically transparent and electrically conductive layer *F* on the glass bulb *G*. The deflecting electrode *D* consists of two electrically inter-connected control rods which are arranged parallel to the cathode axis. The diaphragm *C* screens the mica discs *H* in the discharge space of the picture system. This prevents the mica discs from picking up unwanted electrostatic charges and interfering with the operation of the system. The width and outer edges of the two luminous strips are determined by the slot-type aperture *J* provided in the diaphragm *C*. The diaphragm is so designed by the arrangement of the angle-piece *K*



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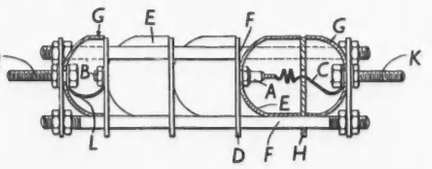
that a deflecting field of high field-strength is formed between the cathode and the deflecting electrode. This field increases the deflection sensitivity of the deflecting electrode. The mica discs *H* are made electrically conductive in the part marked *L*. The part of the mica disc adjacent to the luminous screen *E* is made to press against the wall of the bulb. This provides an electrically conductive connection of the electrically conductive layer *F* applied to the bulb, over the mica disc to the diaphragm *C*. The positive anode voltage of the picture system is applied to the diaphragm. The assembly formed by the cathode, a control electrode *M*, the anode *N*, and part of the grid acting as a suppressor and shielding grid, constitutes an amplifier system. The amplifier current is controlled by the electrode *M*. In the embodiment shown this electrode consists of two round rods. These are electrically connected together, and can form one unit—in the shape of a hairpin, for example. In accordance with the invention, in order to obtain stronger control of the amplifier current, the number of rods forming electrode *M* can be increased to three, four, or even more.—*June* 2, 1960.

838,039. June 17, 1958.—SEMICONDUCTOR RECTIFIER STACKS, Standard Telephones and Cables, Ltd., Connaught House, 63 Aldwych, London, W.C.2. (*Inventor: Norman Colston Brooks.*)

The object of the present invention is to provide stack constructions for power diodes giving good heat dissipation with economy in size. It comprises an in-line stack of crystal diodes comprising a cooling plate per diode and end plates, together having an envelopal cylindrical form with semi-spherical ends provided with cooling slots. In the form of assembly shown in the drawings, mainly for use in high voltage equipments, the power diodes *A* are of the " top hat "



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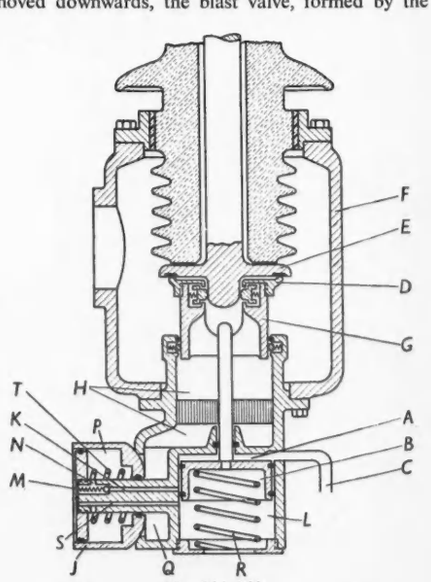
type terminating at the base end in a screwed terminal and mounting stud *B* and at the other end in a coaxial braided flexible lead *C* covered with insulating sleeving. The diodes are bolted to the centre of three-armed insulating spiders *D*. Before inserting the terminal stud into the spider hole, a centrally-apertured cup-shaped metal cooling fin *E* is placed on the terminal stud so that the fin is clamped between the diode and the spider. In the stack shown three such sub-assemblies are threaded on three mounting rods *F* of insulating material which pass through holes in the ends of the spider arms. Two shallower bowl-shaped fins *G* serving as electrostatic shields are independently mounted on spiders and provide roughly semi-spherical ends to the stack. The open end of the cups *E* all face one way, but the open ends of the bowls *G* both face inwardly. The open end of one cup faces the open end of one bowl and an additional spider *H* is threaded on the rods between these two parts. The end spiders are bolted to the ends of the rods and clamp the stack members together. The spiders *D* and tension in the rods *F* give adequate stability and stiffness to the stack. Brass terminal studs *J* and *K* are bolted in the centre holes of the end fins and spiders. A wire *L* connects stud *J* and the adjacent base stud *B*, and the wires *C* are clamped to the base studs of the adjacent diodes and to the stud *K* respectively. The envelopal form of the complete assembly is substantially cylindrical with semi-spherical ends, and slots exist between adjacent fins for cooling purposes. Rods *F* may be extended for the mechanical mounting of the rectifier stack, the terminal studs then being used solely for the electrical connections.—*June* 22, 1960.

ELECTRICAL ENGINEERING

838,041. June 25, 1958.—AIR-BLAST CIRCUIT-BREAKER, Allmänna Svenska Elektriska Aktiebolaget, Västeras, Sweden.

The present invention relates to a compressed-air electric circuit-breaker with breaking gaps arranged in compressed-air containers permanently filled with air under pressure and carried by insulator pillars. By the arrangement shown in the drawing there is obtained an insulating distance which is under pressure when the breaker is open, in spite of the fact that atmospheric pressure prevails in the outlet channel for the extinguishing air when the circuit breaker is closed. Referring to the drawing, the breaking gap is opened by the delivery of compressed air to the space *A* above the operating piston *B* through the operating air line *C*. When the operating piston and the movable contact joined with it are moved downwards, the blast valve, formed by the



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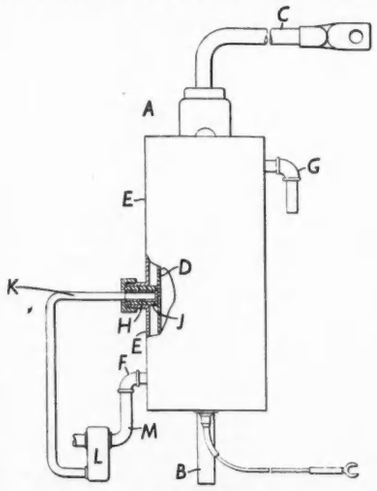
valve disc *D* and the flange *E*, is opened and extinguishing air streams from the container *F* through the nozzle in the movable contact piston *G* into the outlet channel *H*, where normal atmospheric pressure prevails. When the pressure in the outlet opening rises, the blocking valve is immediately opened by the air flow moving the valve member *J* aside. When the piston *B* has reached its lower position, its upper

part has passed the end of the channel *K* in the cylinder *L*, so that compressed air streams from the space *A* through the channel *K*, past the back valve *M* and through the openings *N* to the space *P*. Under the influence of the pressure in this space the valve member *J* is moved to the right and closes the outlet opening *Q*, so that the extinguishing air flow ceases. The breaking gap is closed by evacuating the space *A* above the operating piston *B* through the operating air line *C*. The spring *R* will then move the movable contact to its upper position so that the blast valve is also closed. When the operating piston has reached its upper position, the lower part of the piston will be above the end of the channel *S* in the cylinder *L*. The space *P* will then be in communication with the open air so that air can escape from this space and the valve member *J* will therefore only be actuated against its valve seat by the spring *T*. The air in the outlet channel *H* will then flow out through the blocking valve until atmospheric pressure is established in the channel.—*June* 22. 1960.

838,105. January 16, 1957.—FLUID COOLING OF HIGH POWER DISCHARGE TUBES, Compagnie Française Thomson-Houston, 173, Boulevard Haussmann, Paris (8e), France.

Known temperature control arrangements for high-power electrons discharge tubes have a relatively long time delay in their operation. Accordingly, it is an object of the present invention to provide a control arrangement which is continuously acting and has a short time delay. Referring to the drawing an ignitron electron discharge tube *A* has a



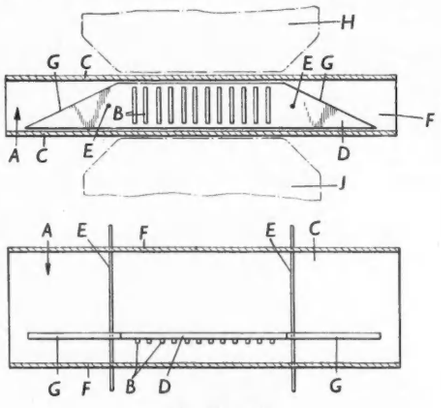
No. 838,105

striking electrode connected to an external conductor *B* and an anode connected to conductor *C*. The envelope of the tube is constituted by two concentric cylindrical members *D* and *E* which define a fluid-tight annular jacket between them for cooling fluid which enters the jacket at inlet tube *F* at the bottom of the tube and emerges through outlet tube *G* on top of the tube. A metal cylinder is attached to the envelope of the tube and is arranged to be in good thermal contact with the internal wall of the envelope. It is surrounded by an insulating sleeving *J*, which may be formed of a plastic material impervious to the cooling fluid at the operating temperature of the tube. Cylinder *H* is filled with a liquid having a relatively high coefficient of expansion, i.e. the difference between the coefficient of expansion of the liquid and coefficient of expansion of this contact cylinder should be as large as possible. A capillary tube *K* connects the liquid in the cylinder to hydraulic regulator *L* which controls the flow of cooling fluid in pipe *M*. In operation, changes of temperature of wall *D* cause expansion or contraction of the fluid in cylinder *H* and this change in volume is communicated by capillary tube *K* to the hydraulic regulator so as to vary the flow of cooling fluid in the jacket to maintain wall *D* at the desired optimum temperature. It will be appreciated that the arrangement can be such that when the temperature of wall *D* is below a predetermined value the cooling fluid is entirely cut-off. This is convenient when warming-up the tube.—*June* 22, 1960.

TELECOMMUNICATIONS

838,149. November 11, 1957.—ELECTROMAGNETIC WAVEGUIDE DEVICES, The General Electric Company, Ltd., Magnet House, Kingsway, London, W.C.2. (*Inventor : John Nevil Rogers.*)

One object of the present invention is to provide a resonance isolator which requires a somewhat smaller magnetic field than other constructions. Referring to the drawings showing sectional elevation (upper) and plan views, the isolator comprises a length of waveguide *A* of uniform rectangular cross-section in which are mounted twelve rods *B* of nickel-zinc ferrite. These twelve rods are equally spaced along the length of waveguide. They are of uniform square cross-section and lie perpendicular to the broader walls *C* of the waveguide. Each of the rods is slightly shorter than the narrower dimension of the wave-

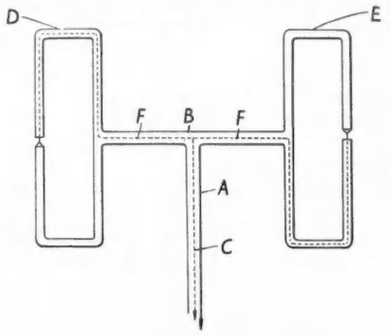


No. 838,149

guide so that each end of the rod is spaced a small distance from the adjacent broader wall. The twelve ferrite rods are carried by a member *D* of polystyrene to which they are secured, for example, by gluing. The member, which is of lamina form, is mounted within the waveguide by means of supporting metal rods *E* so as to lie parallel to the narrower walls *F*. The ends *G* of the member are tapered to reduce the impedance discontinuity within the waveguide presented by the member. The ferrite rods are arranged all to lie in a steady magnetic field which is perpendicular to the broader walls *C* of the waveguide and thus parallel to the rods. This magnetic field may, for example, be provided by means of a permanent magnet, the poles *H* and *J* of which are shown in broken outline. The position of the polystyrene member *G* relative to the narrower walls of the waveguide is chosen so that when, during operation of the isolator, an electromagnetic wave is supplied to the isolator the ferrite rods lie in a region of almost complete circular polarisation of the magnetic field within the waveguide due to the electromagnetic wave. It is desirable for the spacing of the rods to be appreciable so as to avoid interaction between them but in practice some interaction is tolerated to reduce the overall length of the isolator. The magnitude of the steady magnetic field is chosen so that the ferrite material of the rods is in the condition of ferromagnetic resonance when a wave having the frequency at which the isolator is to be used, is transmitted in the appropriate direction along the waveguide. The example of resonance isolator described above has been found to operate satisfactorily at frequencies in the region of 9300 Mc/s when the steady magnetic field is adjustable to a value of about 1080 oersteds. The frequency at which maximum isolation is effected is a function of the magnitude of the steady magnetic field. It is, in fact, found that at frequencies below about 7000Mc/s, it is merely necessary to provide a small biasing magnetic field. This is due to the effect of the demagnetising fields set up in the region of the rods upon the passage of a wave in the appropriate direction along the waveguide. At frequencies greater than 7000 Mc/s the steady magnetic field that is supplied externally is required to increase the electromagnetic wave.—*June* 22, 1960.

838,248. December 17, 1957.—ADCOCK DIRECTION FINDER, Tesla Narodni Podnik, 186, Podebradska, Prague IX, Czechoslovakia. (*Inventor : Miroslav Prochazka.*)

Direction finders of the Adcock type consist of two symmetrical dipoles which are arranged vertically and are constructed either as simple or as composite dipoles. In order to obtain the desired phase displacement of dipole currents, the symmetrical feeder to the dipoles is crossed. With this symmetrical construction, it is difficult to obtain electrical symmetry, and the coupling of such a construction to the receiver also involves difficulties. According to this invention an improved Adcock direction-finder consists of a pair of coaxial-fed folded dipoles particularly for short and ultra-short waves wherein the inner conductor connecting the two dipoles is located in the upper half of one dipole and the lower half of the other dipole, both of which lie in the same plane such that the whole arrangement is symmetrical about its centre. In the example illustrated the supporting construction consists of two tubes *A* and *B* arranged to form a "T" junction and which in addition to acting as supports, form the members of the antenna system. Two tubular dipoles are secured to the ends of the transverse tube *B* at the zero-voltage points. Thus the whole antenna system is made of tubes which also form the outer conductor of the coaxial feeder. The inner conductor *C* which is inserted in the tube *A*, is connected to the middle of the inner conductor provided in the tube *B* and passes into the actual dipoles *D* and *E*. In the left-hand dipole *D*, the conductor *F* passes through the upper arm and is conductively connected to the lower arm of the same dipole ; on the other hand, the conductor *F*, at the other side, enters the lower arm of the dipole *E*. From this it follows that the whole arrangement is symmetrical about the centre. This symmetry is further assured as a result of the fact that the inner conductor which connects the two dipoles is connected, at its electrical centre to the coaxial conductor *C*. The associated receiver, which is not illustrated, is coupled to the coaxial line *A*, *C*. The characteristic impedance of the coaxial line *B*, *F*, and the distance between the two dipoles *D* and *E* are adapted so as to obtain an



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impedance covering as wide a band as possible and at the same time to receive a band as wide as possible. The system has a very high electrical symmetry ; it can be tapped directly to the coaxial input of the receiver, the effect of interference currents on the connecting line between the antenna and the receiver is greatly suppressed. The impedance of the direction-finder is sufficient for the required wide wavebands and the direction-finder is electrically very simple. The conducting connection between the individual antenna members and the earthed supporting structure protects the whole system from static charges, as a result of which the noise voltage is reduced.—*June* 22, 1960.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

BRITISH INSTITUTE OF MANAGEMENT

Wed., July 20.—Connaught Rooms, London, W.C.2, One-day conference on "A Practical Guide for Management Decisions," 9.45 p.m.

BRITISH INTERPLANETARY SOCIETY

Today, July 15.—Kent Room, Caxton Hall, London, S.W.1 Annual General Meeting, 6.30 p.m.

INSTITUTE OF METALS

Mon., July 25.—Royal Institution, Albemarle Street, London, W.1, "The Structure of Metals and Intermetallic Compounds," Linus Pauling, 6.30 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

Thurs. to Wed., July 21 *to* 27.—ELECTRONIC AND COMMUNICATIONS SECTION : Olympia, London, W.14, Third International Conference on Medical Electronics, in association with the International Federation for Medical Electronics.

PLASTICS INSTITUTE

Tues., July 19.—British Plastics Federation, 47-48, Piccadilly, London, W.1, Annual General Meeting, 2.15 p.m.

ROYAL INSTITUTION OF CHARTERED SURVEYORS

Tues., Aug. 30, *to Sat., Sept.* 3.—The University College of North Wales, Bangor, Annual Conference, 1960.

Advanced Engineering Courses

Production Engineering. IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY, South Kensington, London, S.W.7. A full-time course in production-engineering commencing in October. The course will be of one year's duration and successful candidates will be awarded the D.I.C. Students will be required to take three compulsory subjects : Industrial engineering ; management and industrial administration, and statistics and statistical methods. Prospective entrants should possess a degree or equivalent, together with some practical experience.

Production Planning and Control. UNIVERSITY OF BIRMINGHAM, Institute for Engineering Production, "Southfield," 16, Norfolk Road, Edgbaston, Birmingham, 15. Residential executive course, September 19 to 30. The primary aim of the course is to discuss methods of production planning and control and the application of systematic analysis to these functions with a view to the improvement or organisational and production efficiency. The course is intended for industrial executives, senior production engineers and controllers, O. and M. personnel and other specialists in related fields. Fee sixty guineas.

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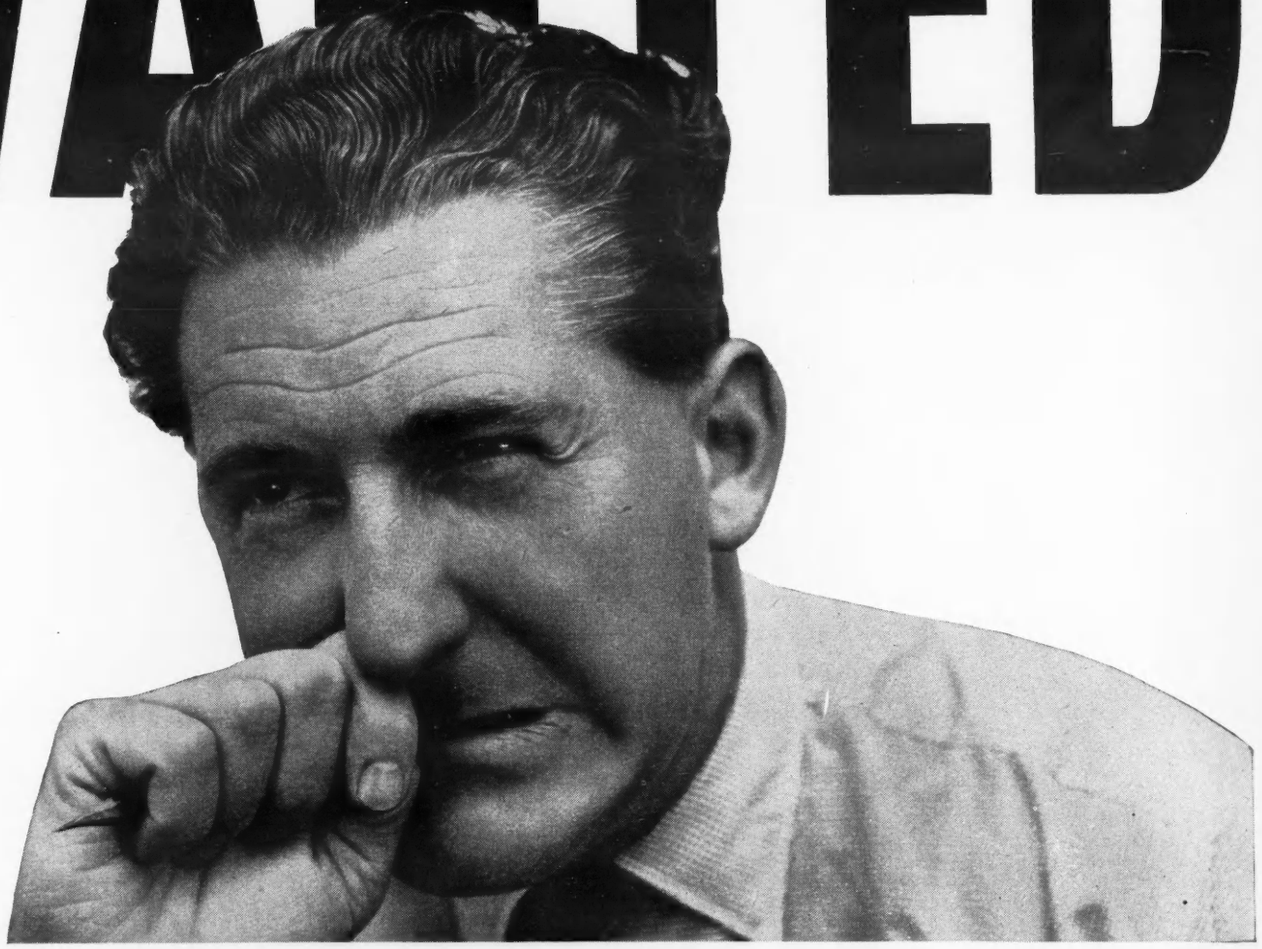

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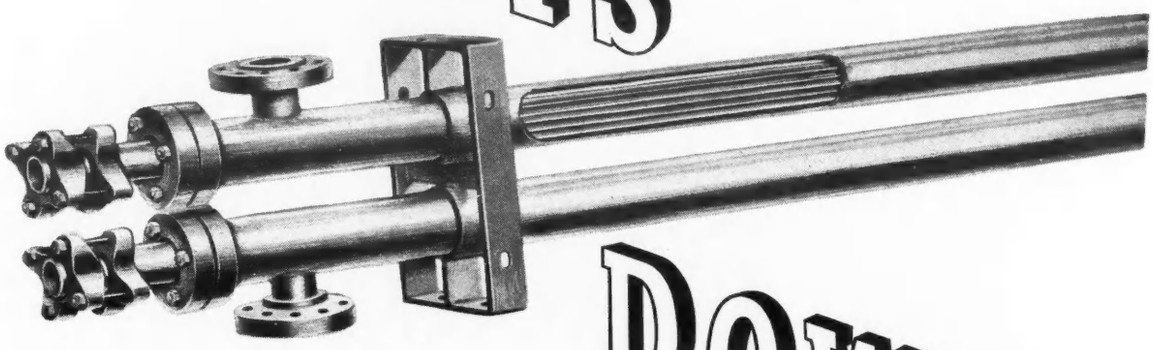

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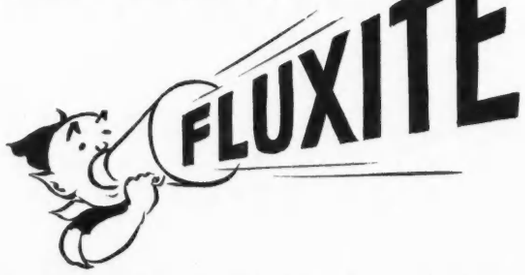

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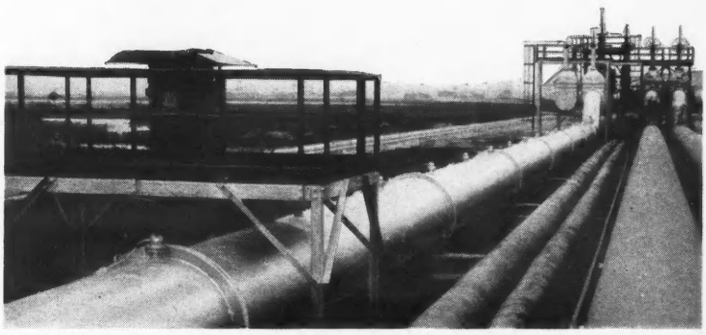

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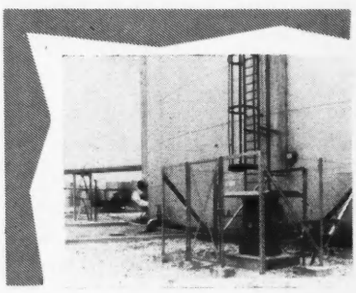

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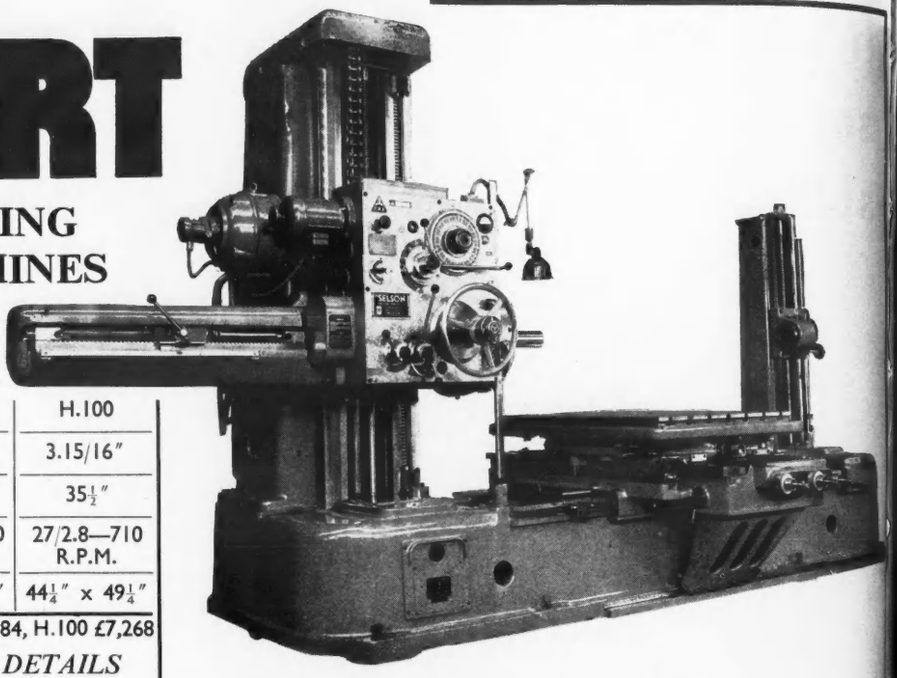

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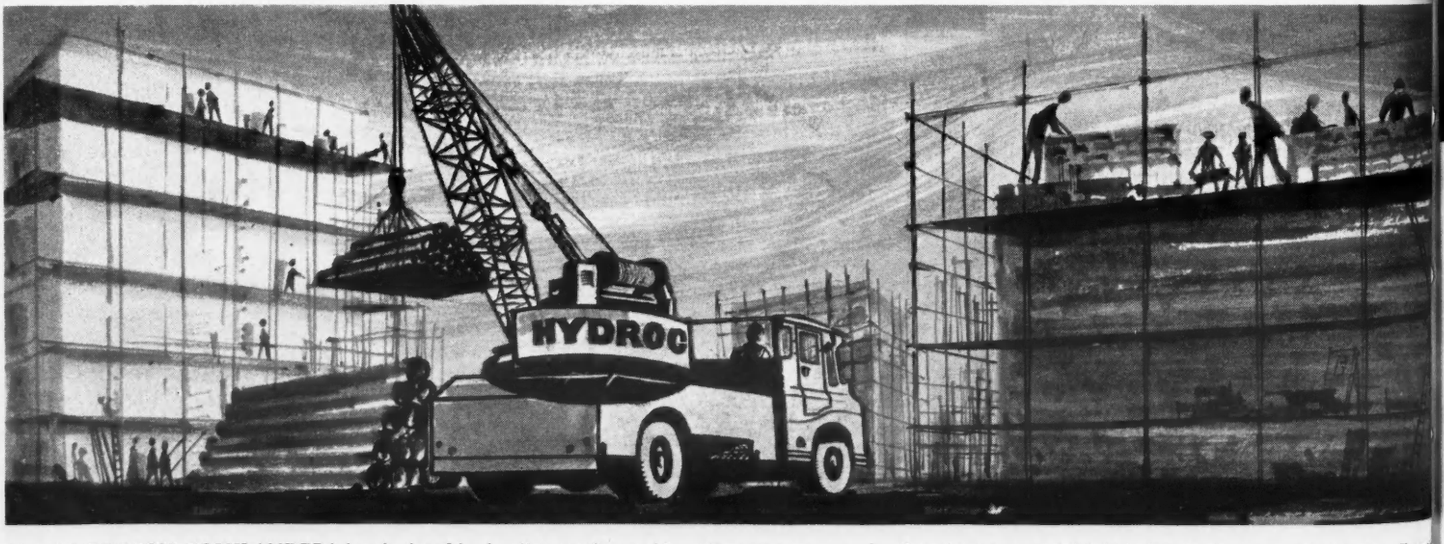

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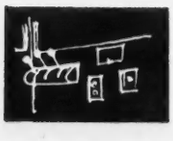

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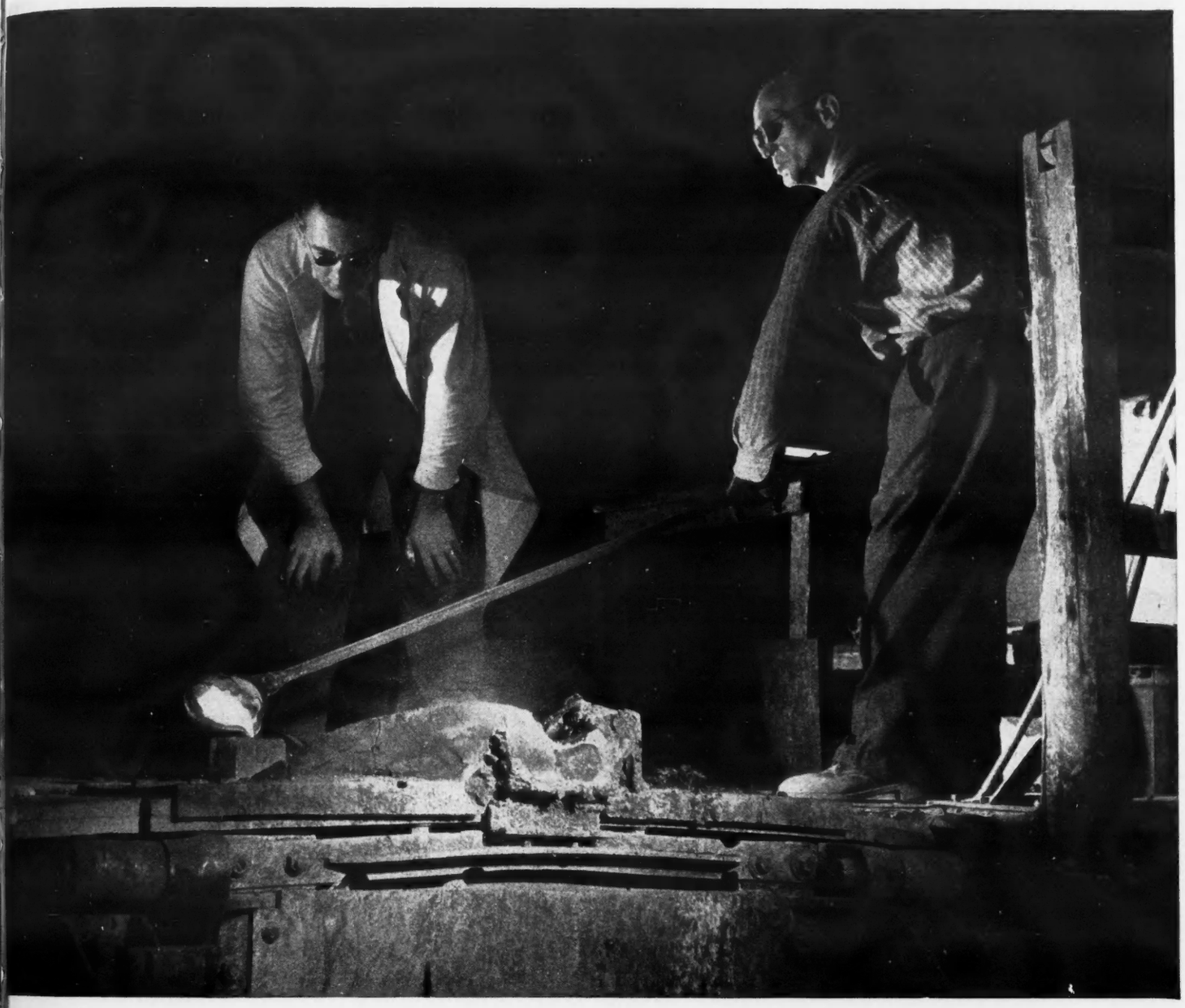

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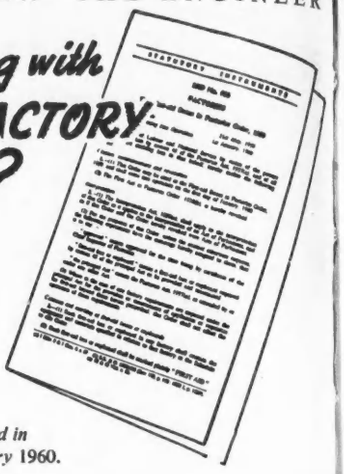

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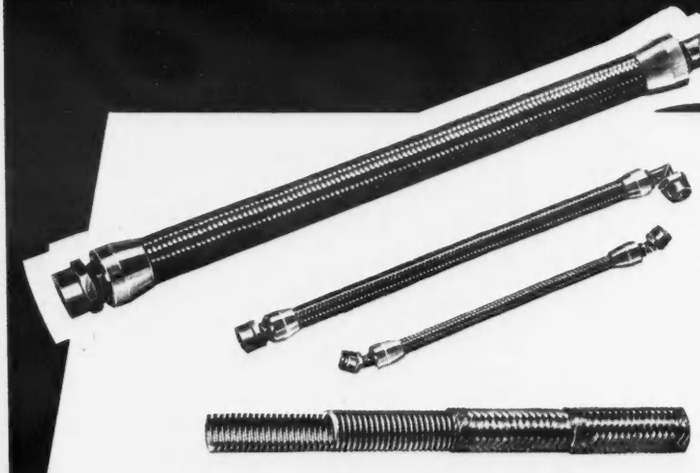

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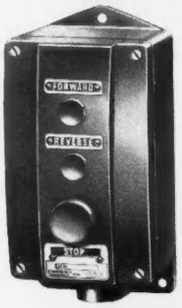

Watertight pattern surface mounting 3 CSU/W "Forward"—"Reverse"—"Stop"

Watertight pattern surface mounting 33 CSU/W "Start"—"Inch"—"Stop"

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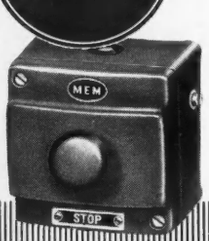
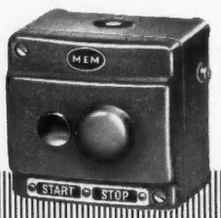


Surface mounting enclosed pattern 1 CSU "Stop" only

Surface mounting enclosed pattern 1 CSU/L Push to lock "Off" Turn to release



Surface mounting enclosed pattern 2 CSU "Start"—"Stop"

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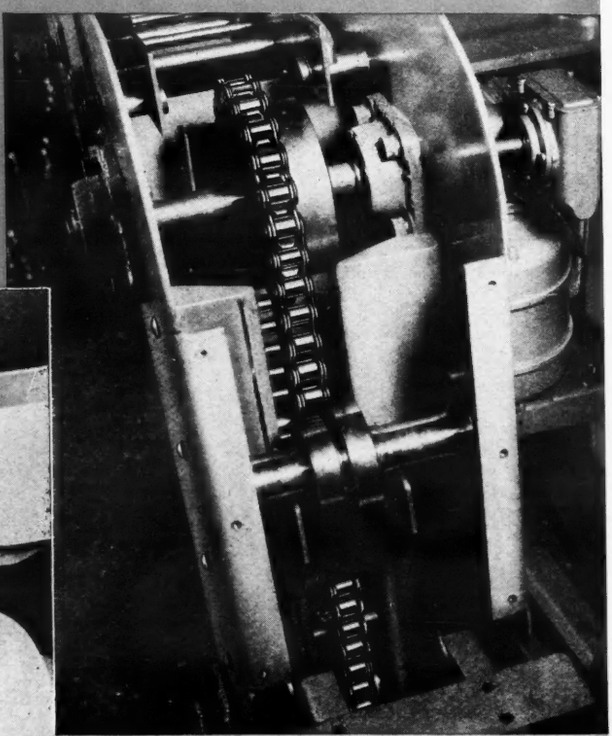

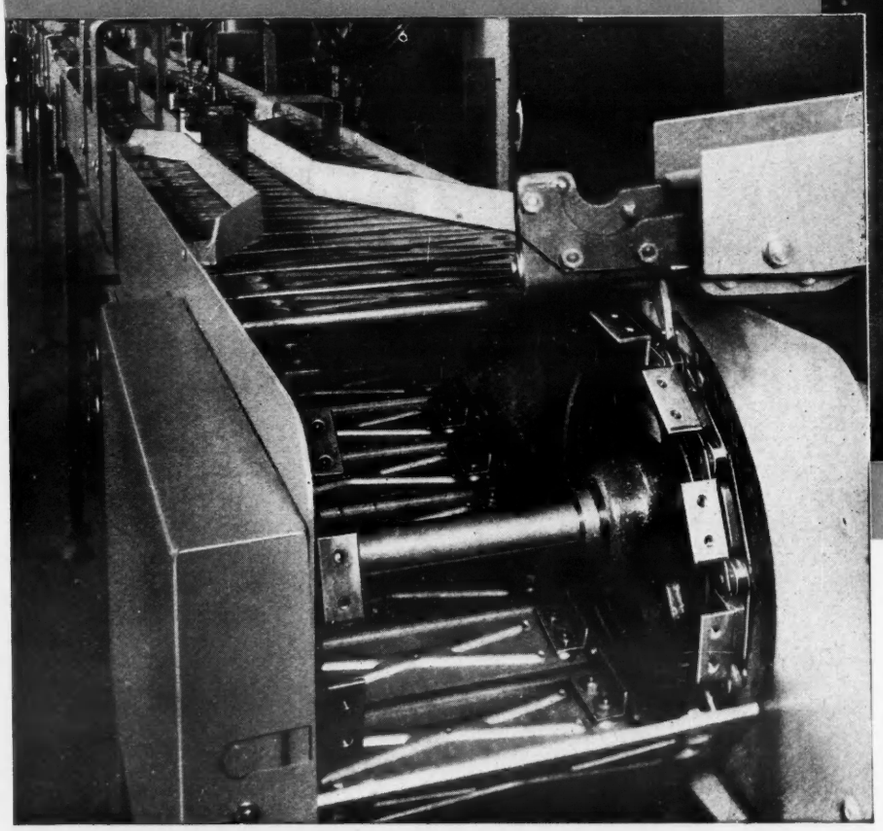

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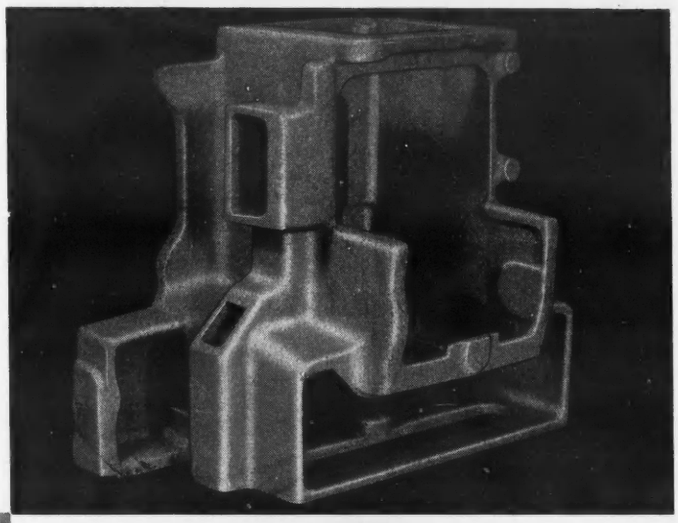

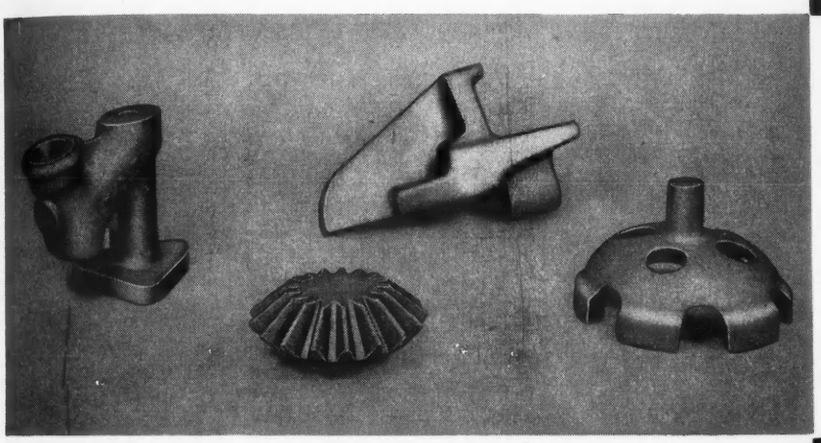

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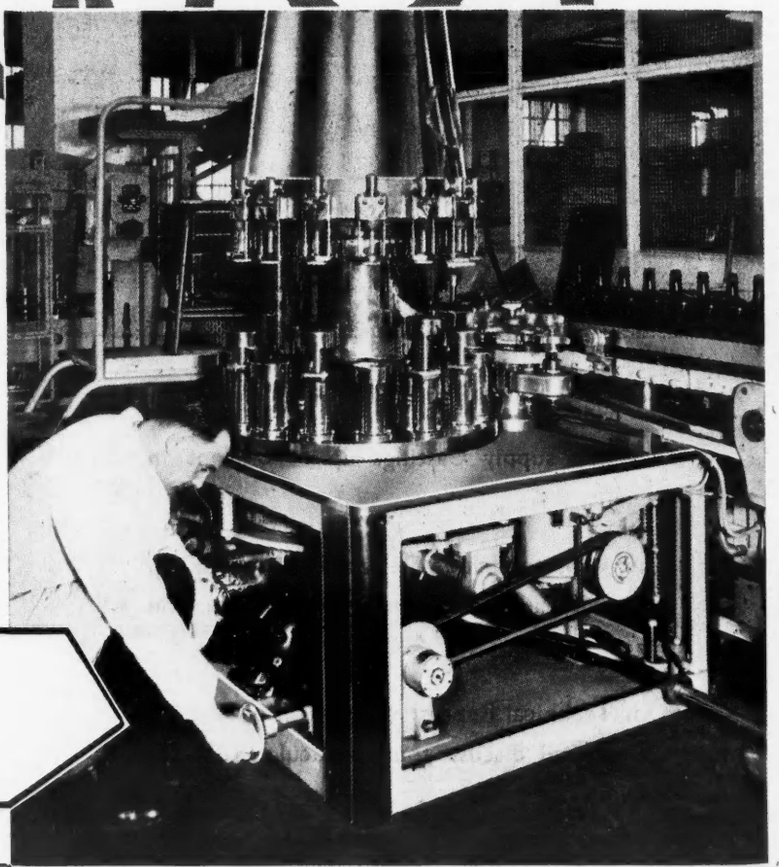

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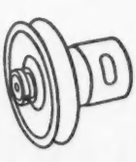

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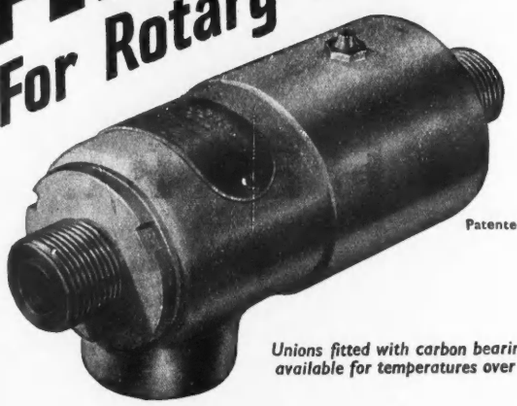

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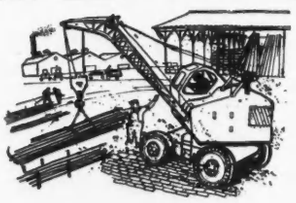

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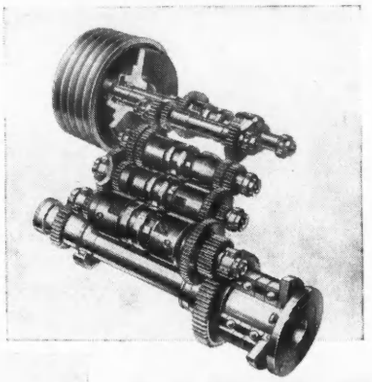

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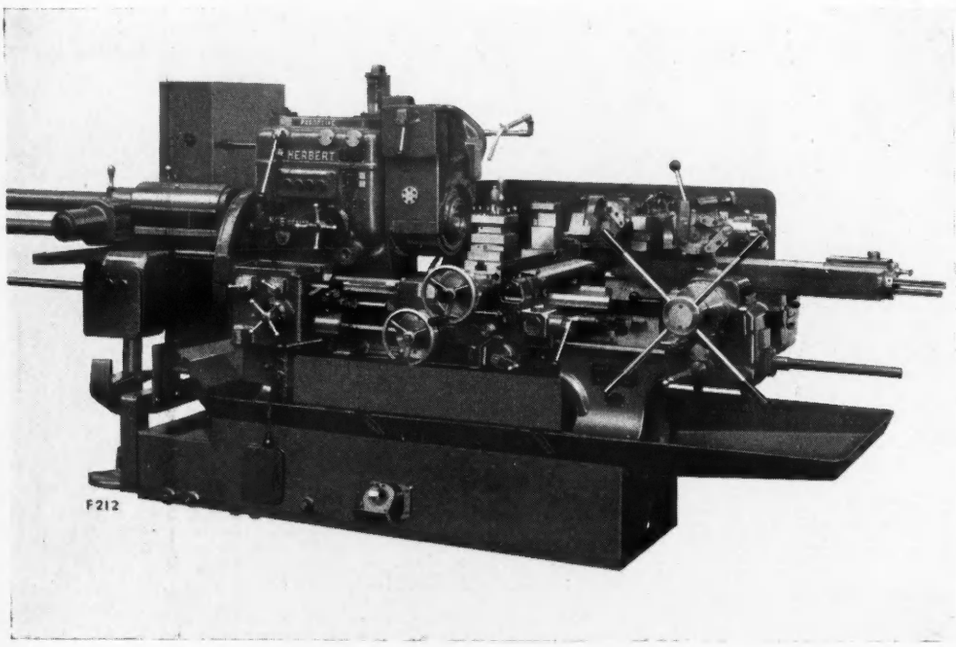

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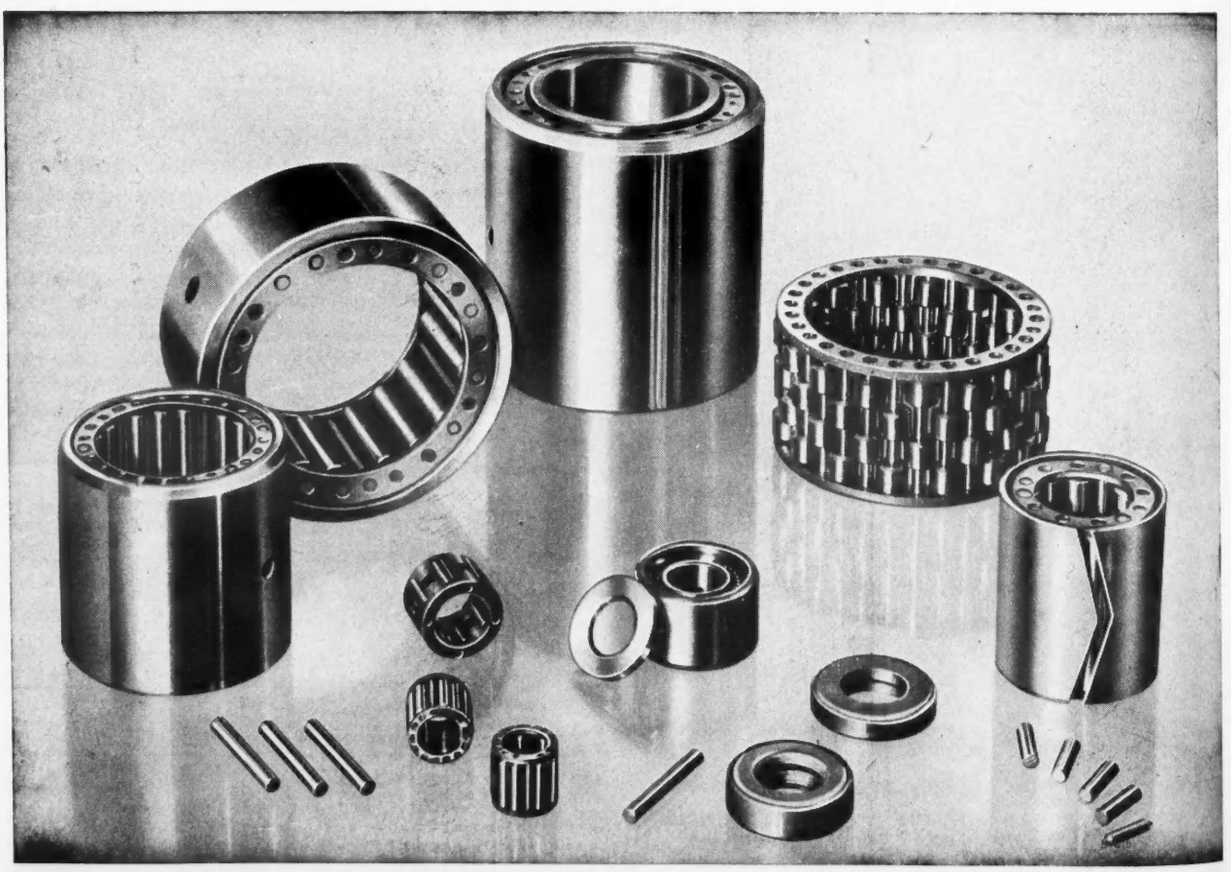

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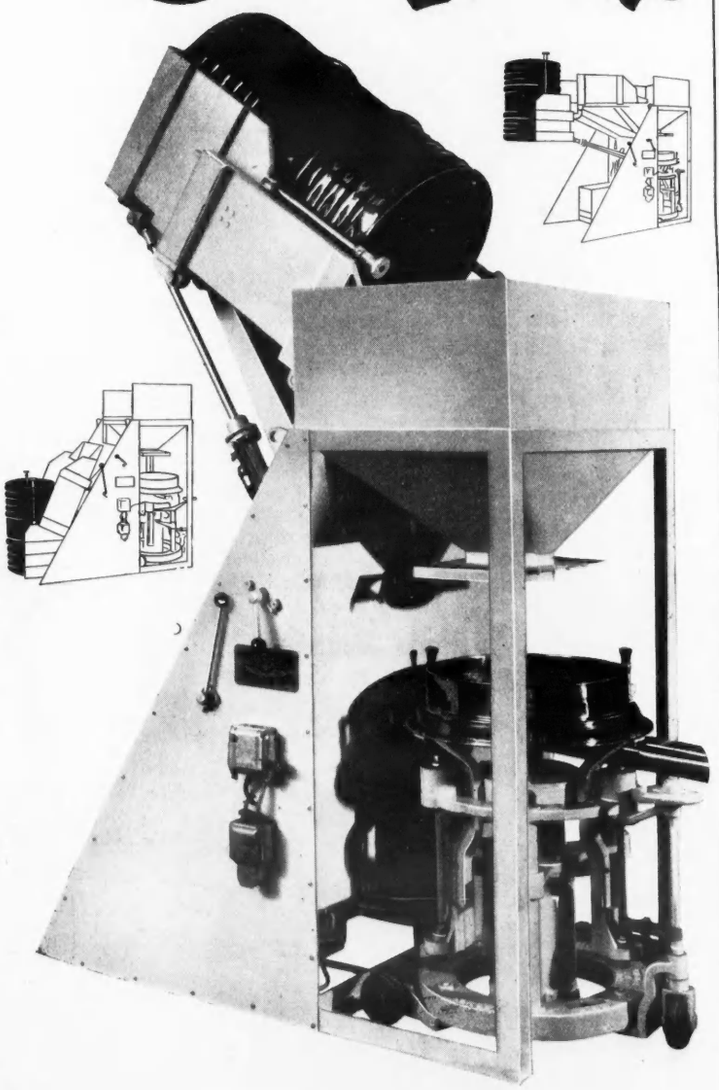

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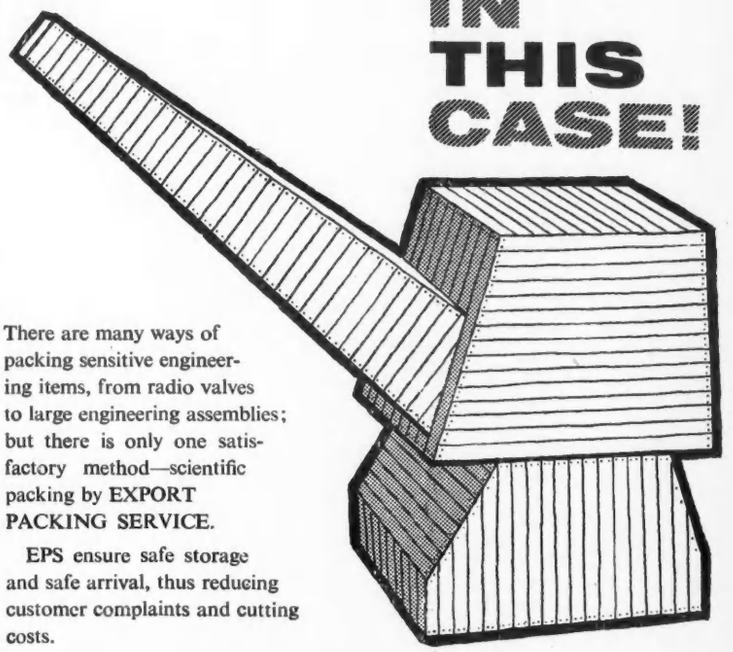

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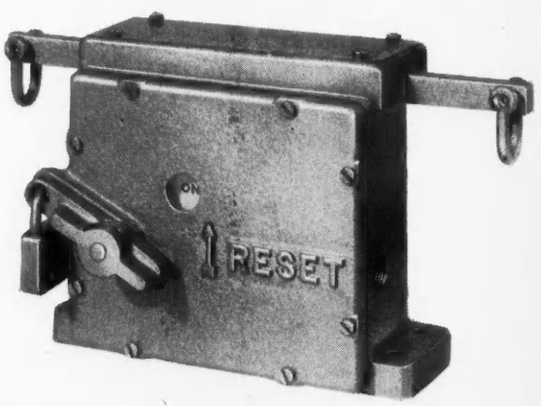

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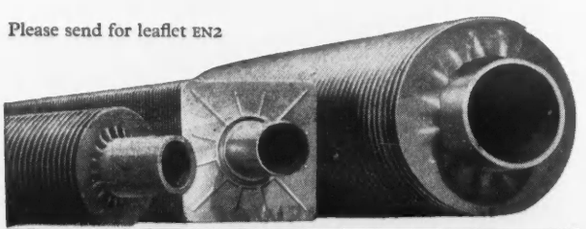

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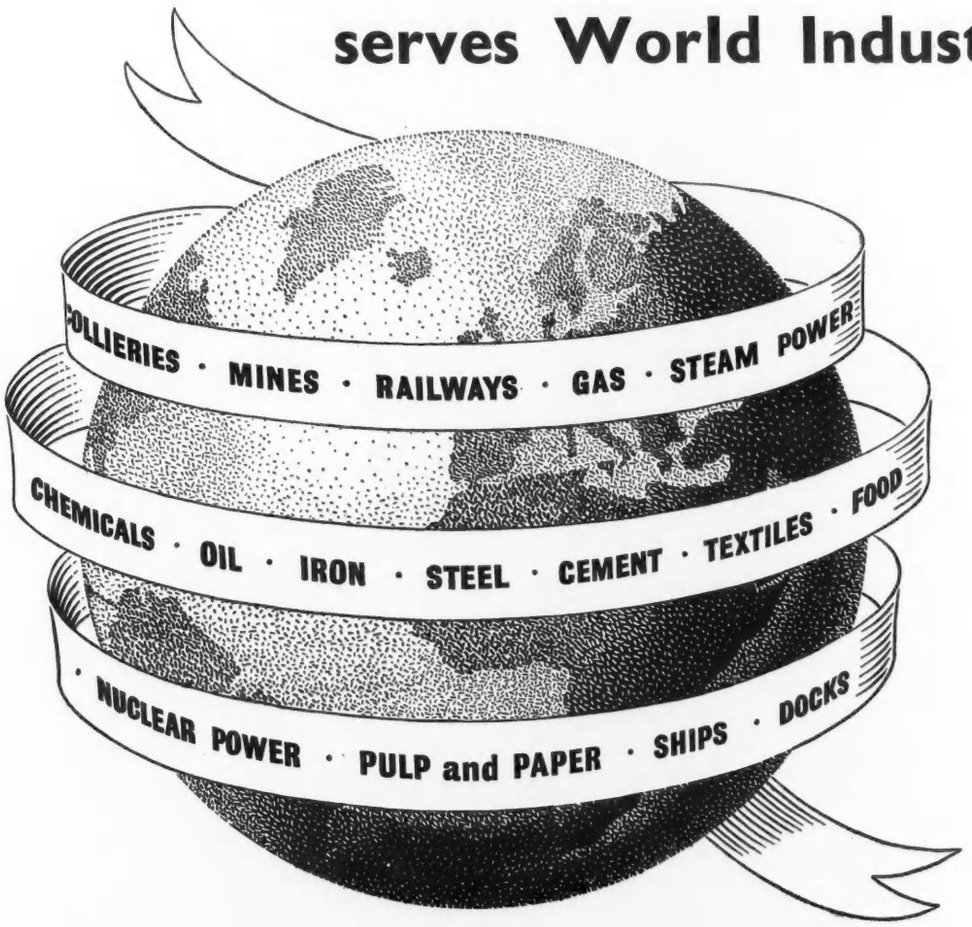
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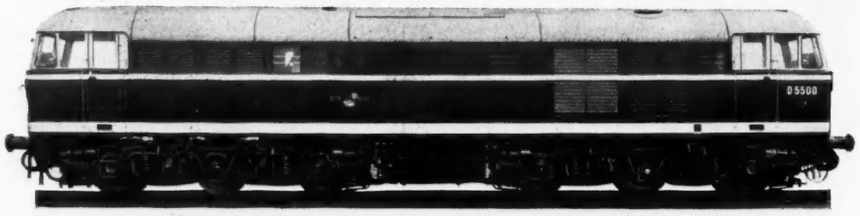

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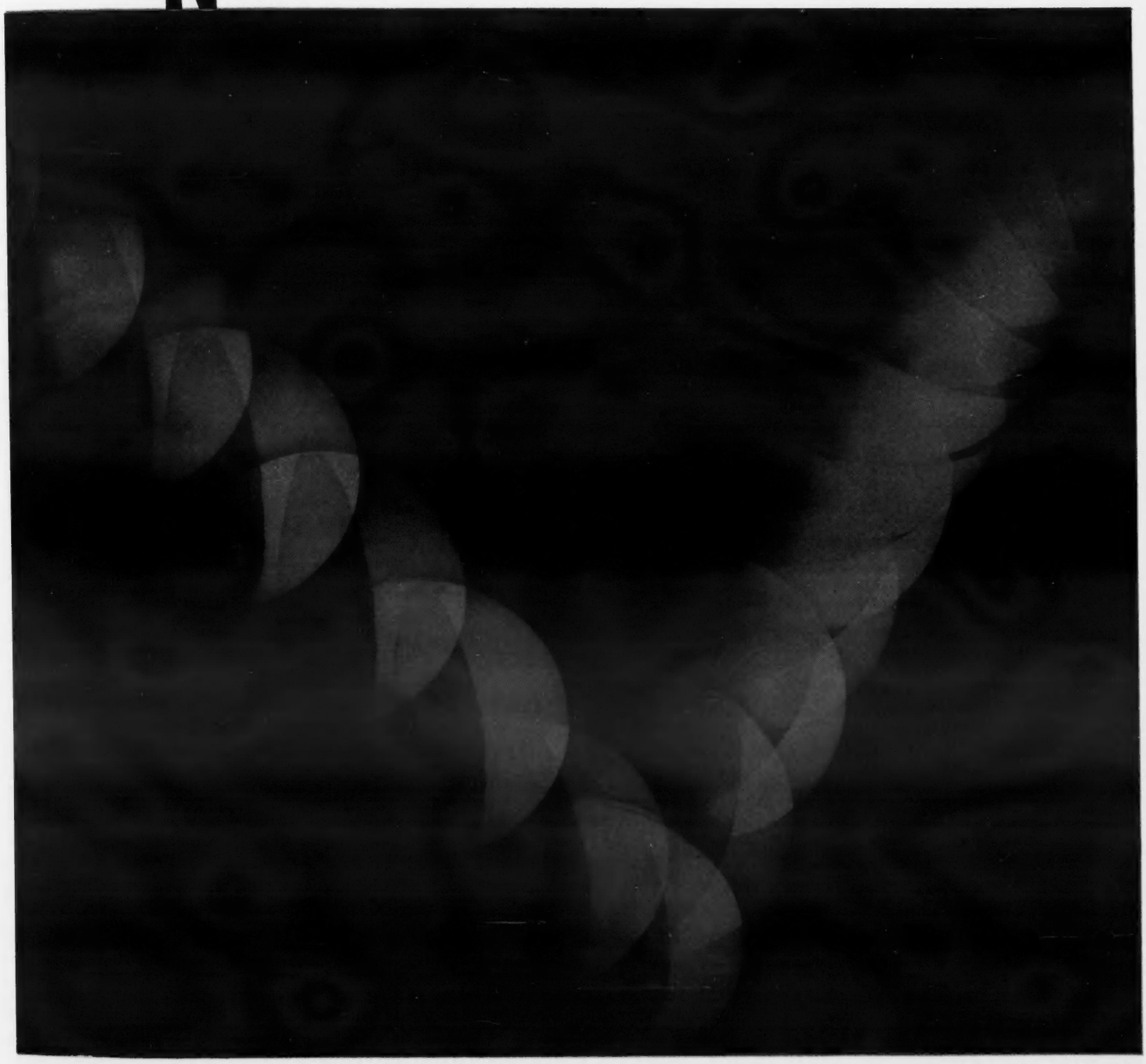

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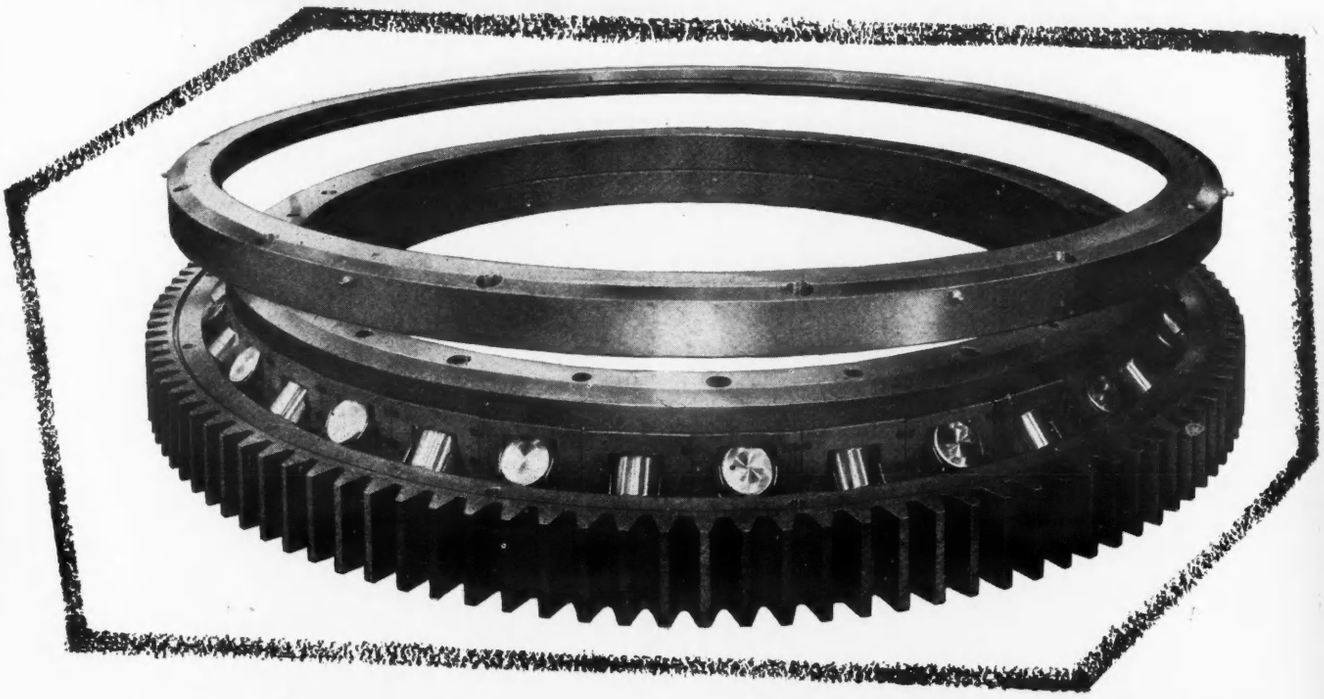
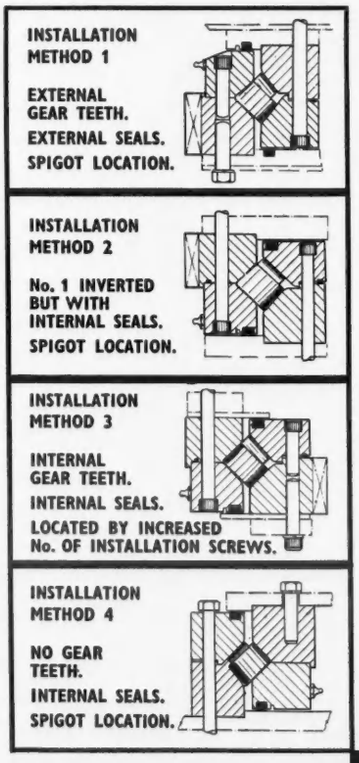


"Packaged" SLEWING RING



SIMPLICITY AND ECONOMY OF INSTALLATION

The bearing is supplied assembled, pre-loaded and lubricated, only fitting in position is required.

NO CENTRE POST REQUIRED

This leaves a large area on centre line free to accommodate controls, power cables and other services.

RIGID OPERATIONAL STABILITY

The principle of twin paths and pre-loaded cross rollers effectively interlocks crane superstructure and base, eliminating "rock".

VIRTUALLY MAINTENANCE FREE

Except for lubrication approximately twice a week (to recharge labyrinth seal) no maintenance required between major plant overhauls.

PRECISION MANUFACTURE

Compared with other types of slewing ring, the totally enclosed, pre-loaded, CROSS-ROLL BEARING with precision ground tapered rollers and hardened roller paths sets new standards for the erection of heavy structures.

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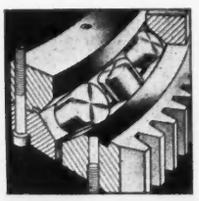

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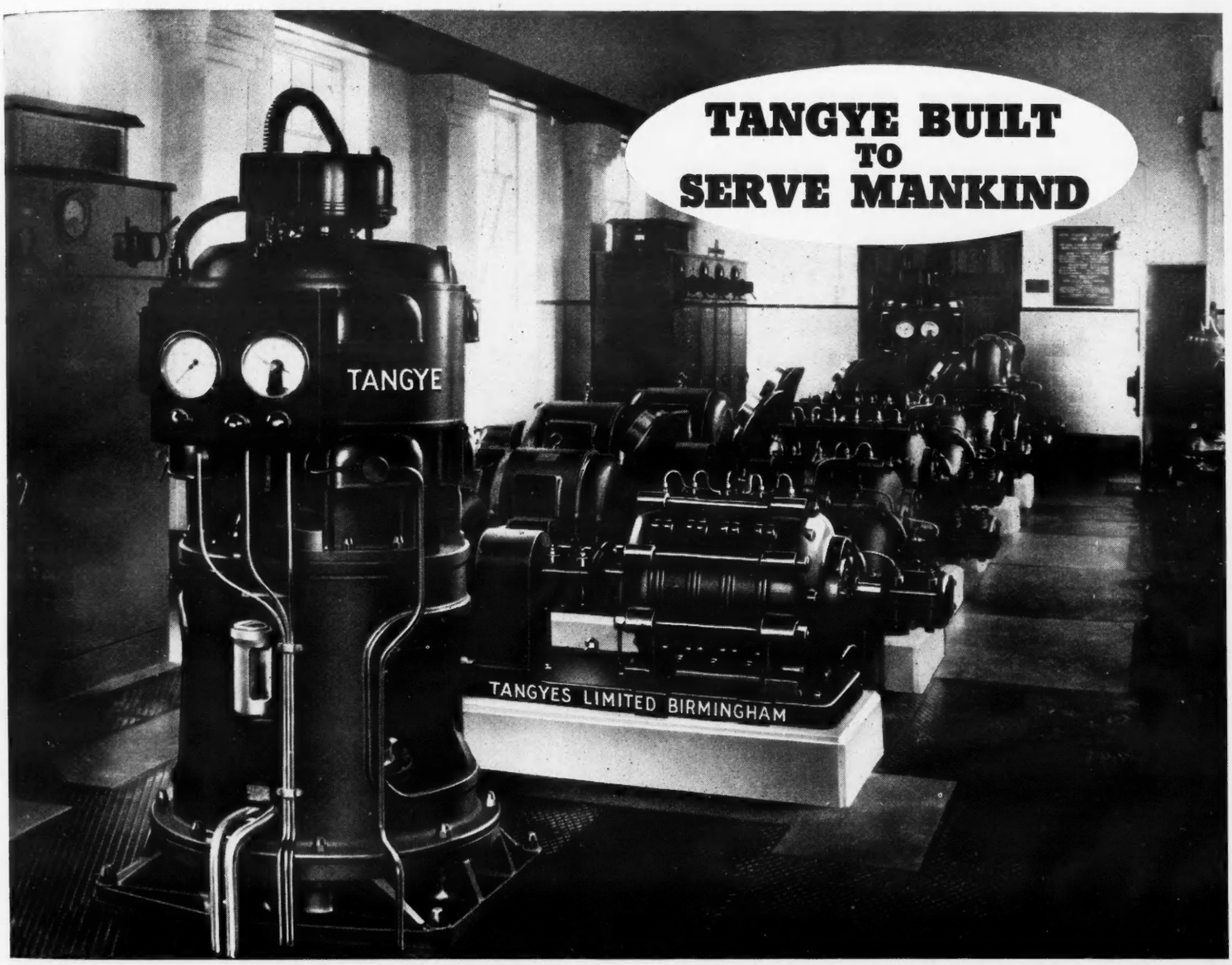


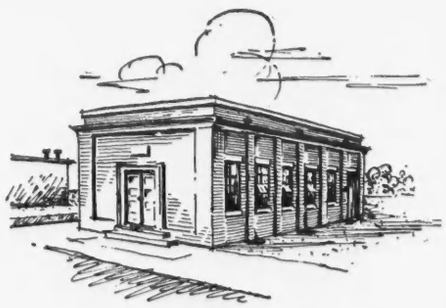
The Mere pumping station, in which Tangye pumping equipment is installed, serving the Rural District Councils of Mere and Tisbury and the Rural Council of Shaftsbury.

Consulting Engineers:— Messrs. Ward Whitfield & Son, Trowbridge.

There is a real satisfaction in supplying equipment which is destined to be of direct benefit to countless thousands. Take pumping for example.

May be that most of the general public (we admit, with justification) accept the convenience of fresh clean water, piped into the comfort of their own home, as their unquestionable right. But there are also many who do not cease to wonder at the magic of our modern society and give thought and credit to the Consultants, the Surveyors, and numerous Engineers, whose main endeavours are to ease the burden of their fellow men.

Tangyes Limited are proud of their long association with Consulting Engineers and Surveyors and numerous public servants to whom we owe so much.



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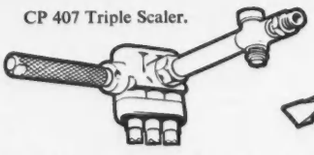

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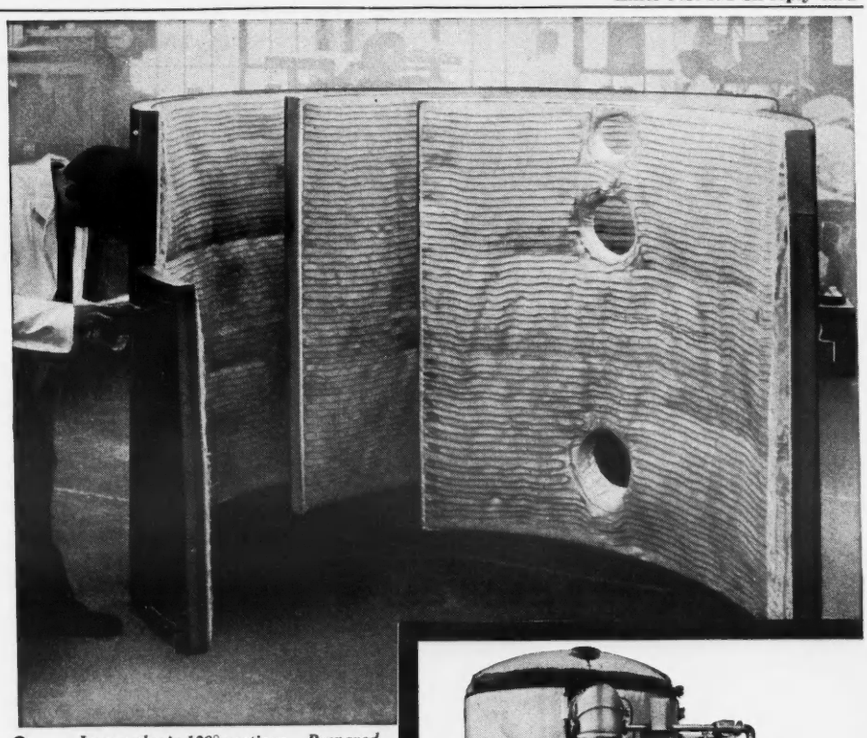
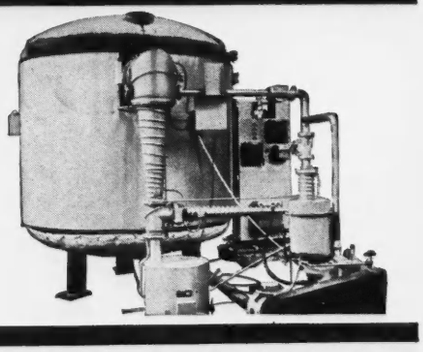


Isomantles in 120° sections. Prepared for vacuum chamber by Edwards High Vacuum Ltd.



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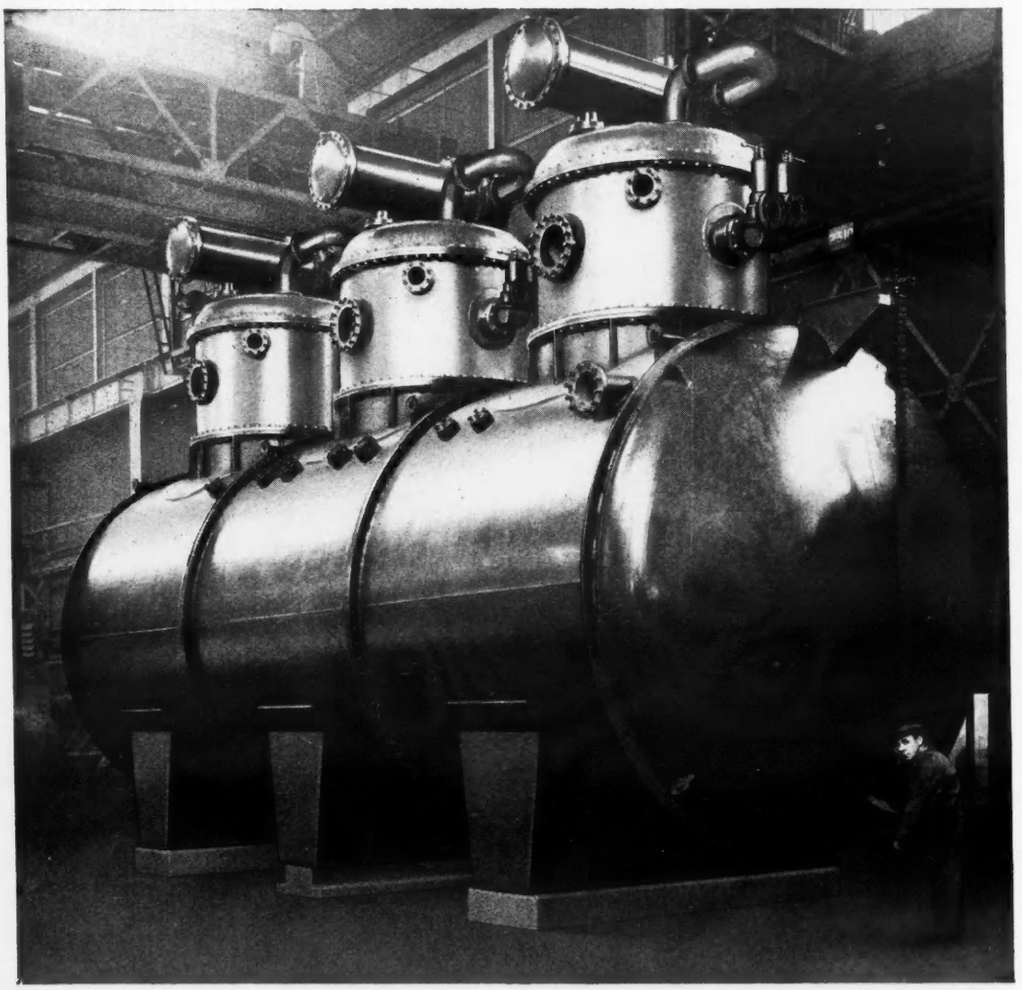

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This elastomer has excellent resistance to oil, grease and most chemicals. It resists abrasion, cutting, chipping and flex cracking. In addition, it withstands sunlight, weathering and ozone.

Du Pont neoprene is ideal in cable jacketing, adhesives, colliery, conveyor and transmission belts, and in hose for oil and chemicals.

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Hypalon* is *completely* ozone-proof and is one of the few elastomers that can be compounded in an unlimited range of stable colours. It shows outstanding resistance to strong oxidising chemicals, such as concentrated sulphuric and chromic acids; and it withstands heat (at temperatures up to over 300°F.), abrasion, sunlight and weathering.

Du Pont Hypalon is ideal in coloured jacketing for wire and cable, coated fabrics, in protective and decorative coatings, for tank linings to hold oxidizing chemicals, hot materials belting, and white sidewalls for tyres.

VITON—a fluoroelastomer unsurpassed in fluid and heat resistance

This elastomer is unequalled for service in oils, solvents and chemicals at over 400°F., and resists most of the new fuels and lubricants used in jet aircraft. With its strong resistance to compression set, even at high temperatures, Viton* is ideal for gaskets subjected to heat.

Vulcanizates of Viton in any hardness of from 60 to 95 durometer, demonstrate a tensile strength, at room temperature, of up to 3000 psi., and ultimate elongation of up to 400%. Combining these properties with a high resistance to oxygen and weathering, Viton is an ideal material for precision seals, valve seats, diaphragms and coated fabrics.

In certain services, Viton has given satisfactory performance as low as —65°F.

	NEOPRENE	HYPALON	VITON
Hardness Range	40 to 95 Shore A	40 to 95 Shore A	60 to 95 Shore A
Tensile Strength	over 3000 psi	over 3000 psi	over 2000 psi
Temperature Range	—60°F. to +250°F.	—30°F. to +350°F.	—40°F. to 600°F.
Adhesion to Fabrics	Excellent	Good	Good to Excellent
Adhesion to Metals	Excellent	Excellent	Good to Excellent
Chemical Resistance	Good	Good to Excellent	Excellent
Compression Set Resistance	Fair to Good	Fair	Very Good
Ozone Resistance	Excellent	Outstanding	Outstanding
Flame Resistance	Good	Good	Good
Sunlight and Weather Resistance	Very Good	Outstanding	Very Good
Abrasion Resistance	Excellent	Excellent	Good
Oil Resistance	Good	Good to Excellent	Excellent

*Hypalon and Viton are both registered trade marks of Du Pont elastomers.

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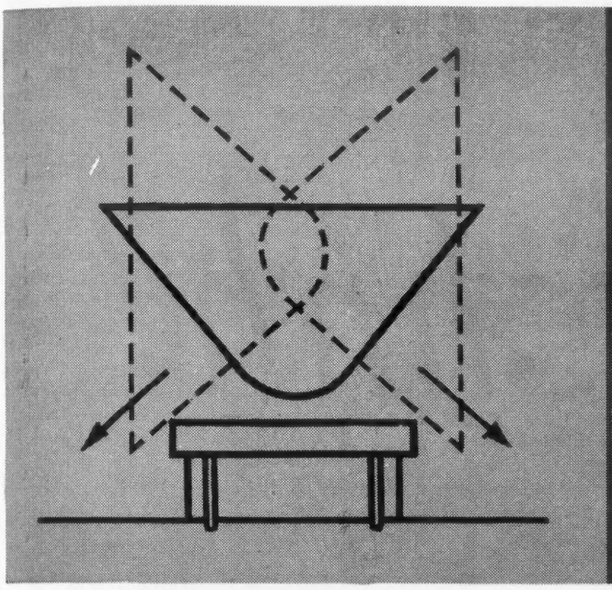
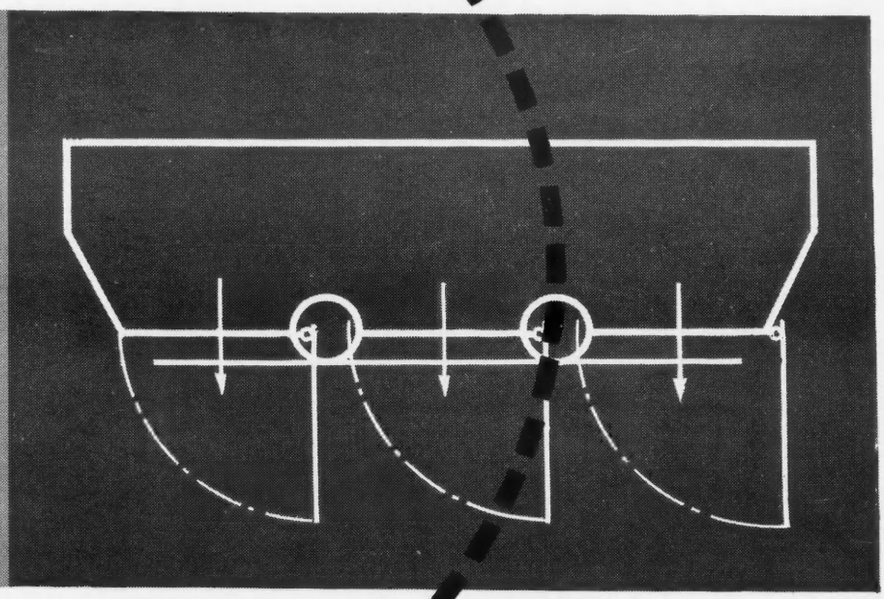
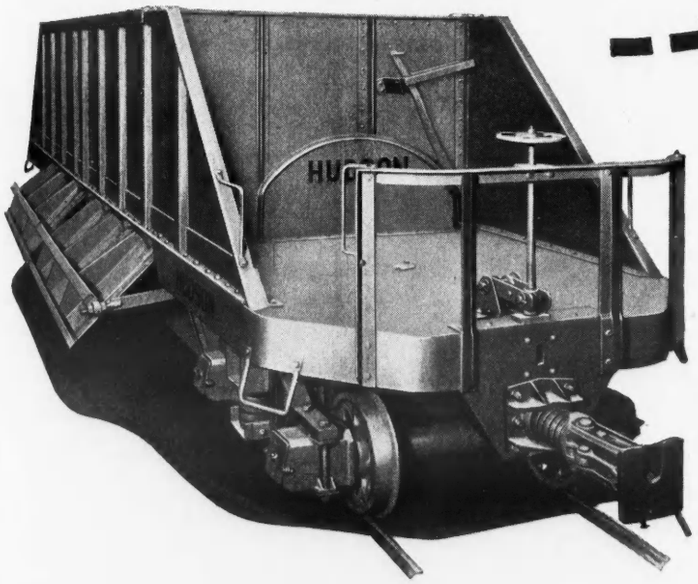


Double Side Tipping Wagon



Three Door Automatic Bottom Discharge Hopper

WITH SIDE AND BOTTOM HOPPERS



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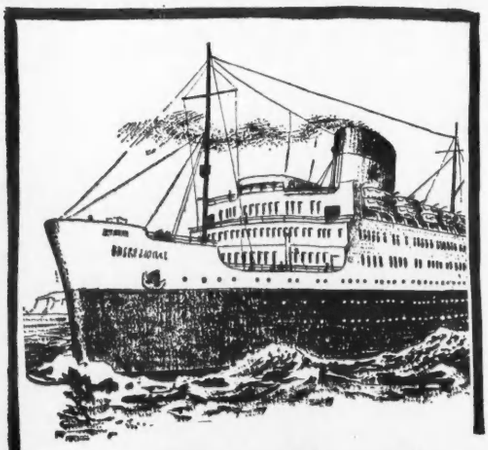

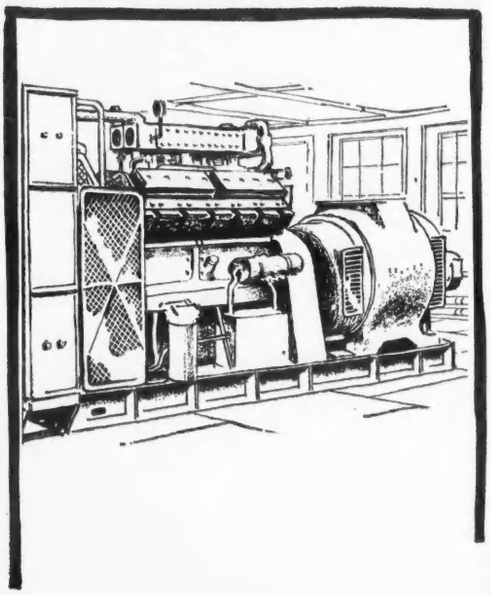

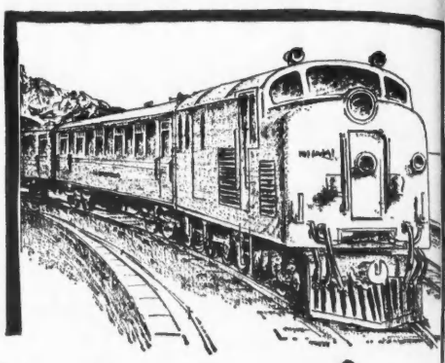

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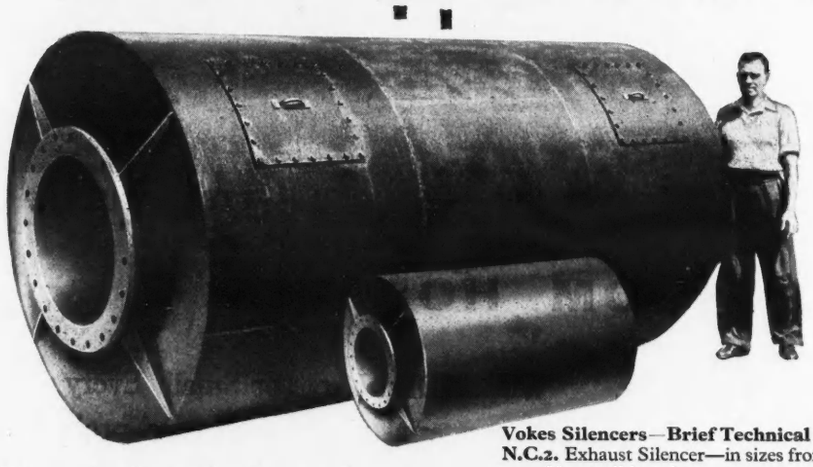

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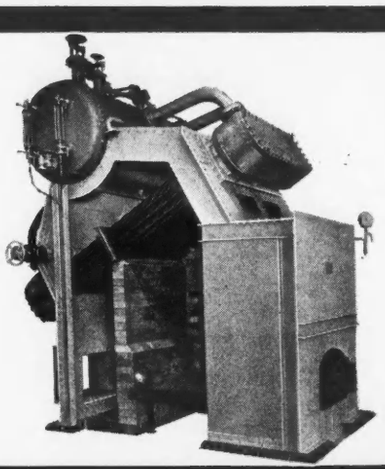

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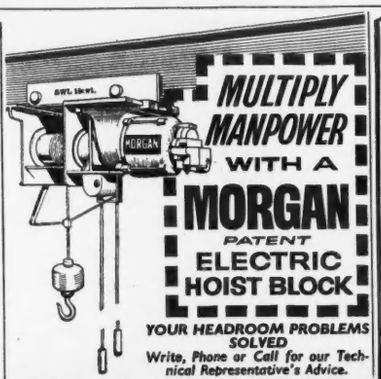

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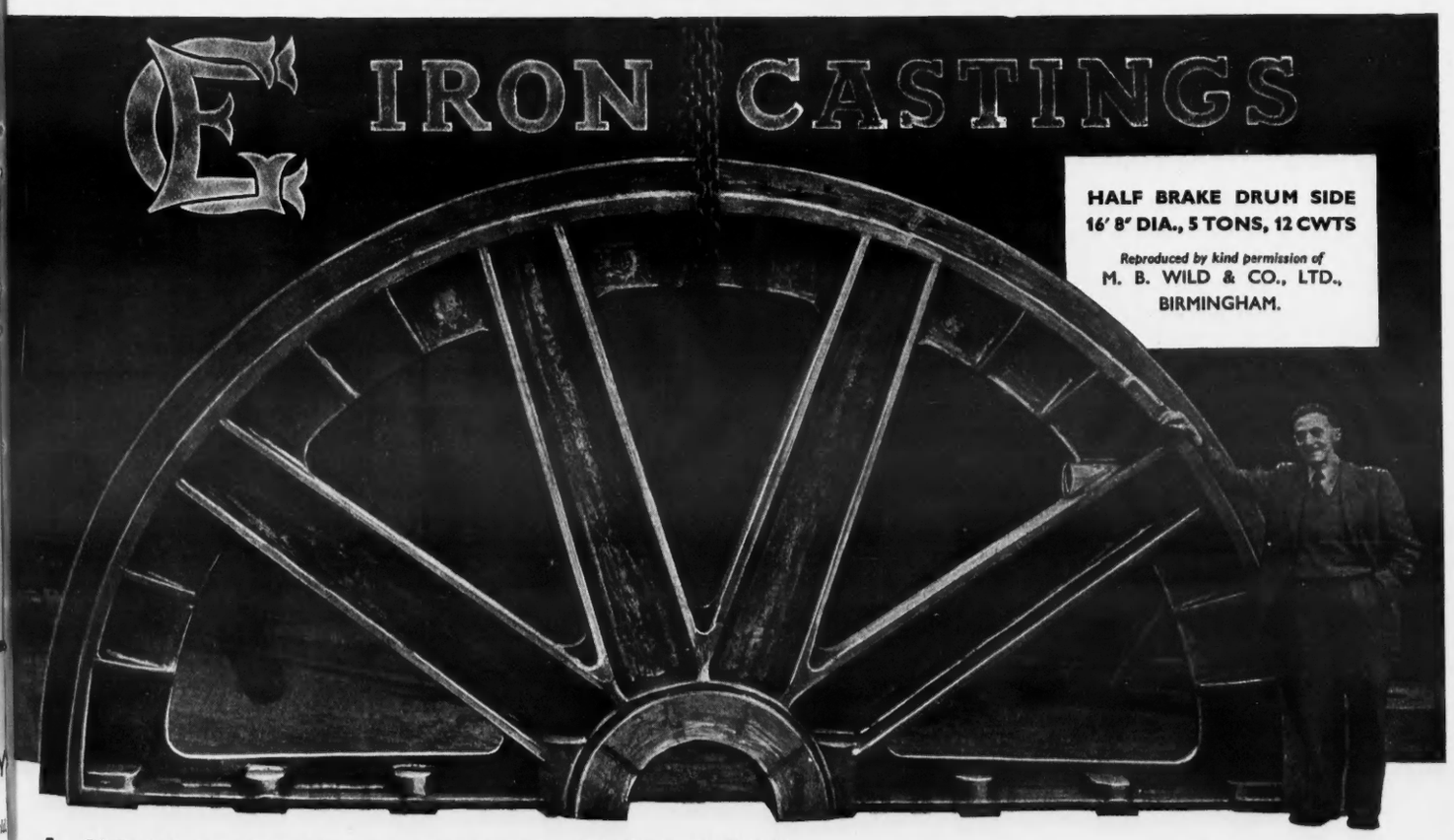

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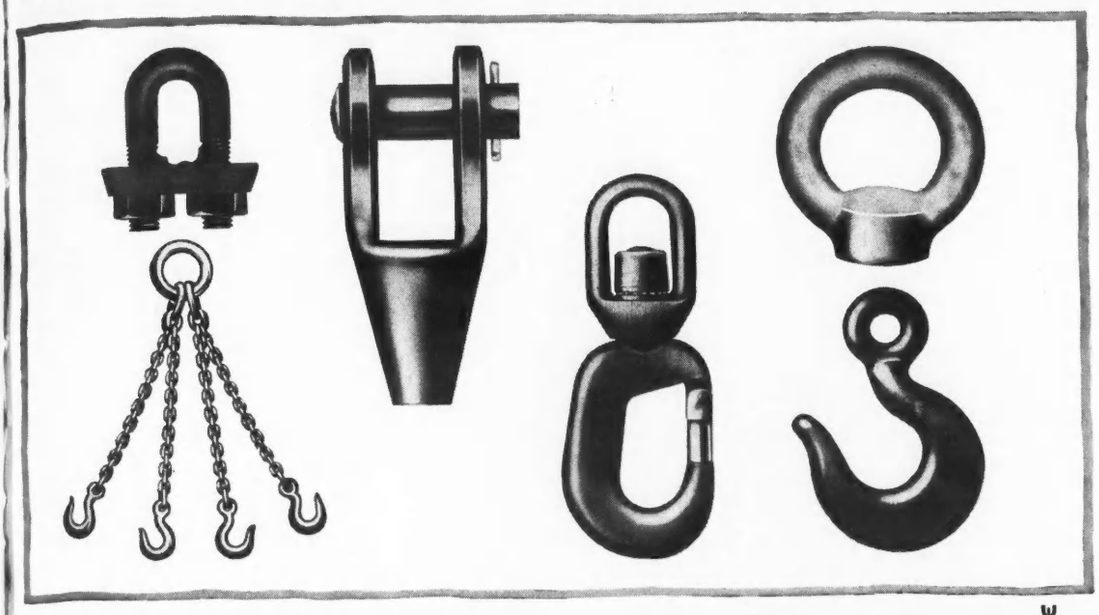

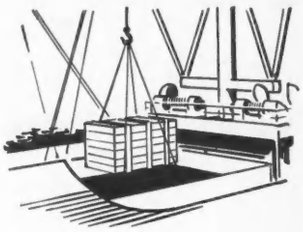

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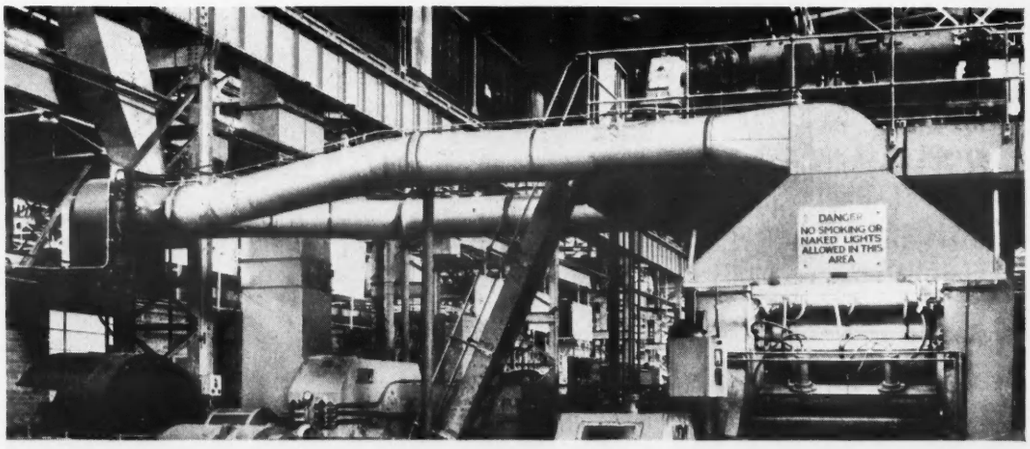

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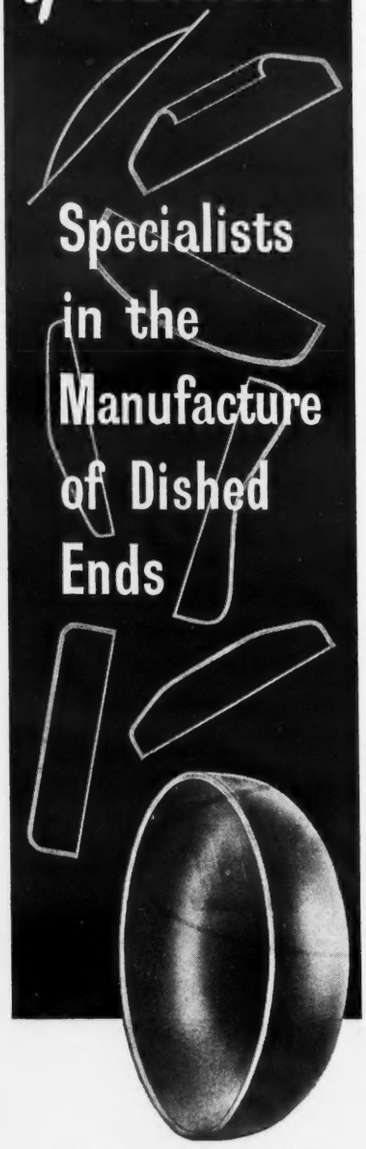

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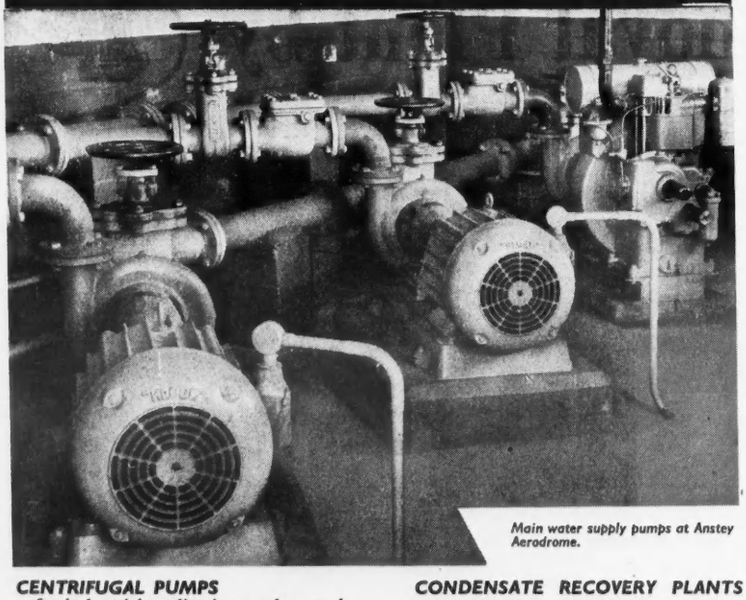

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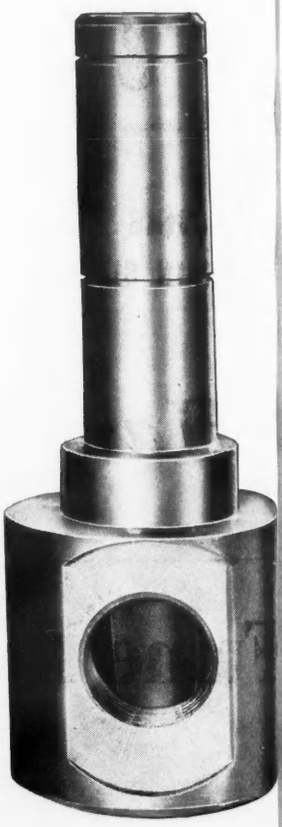

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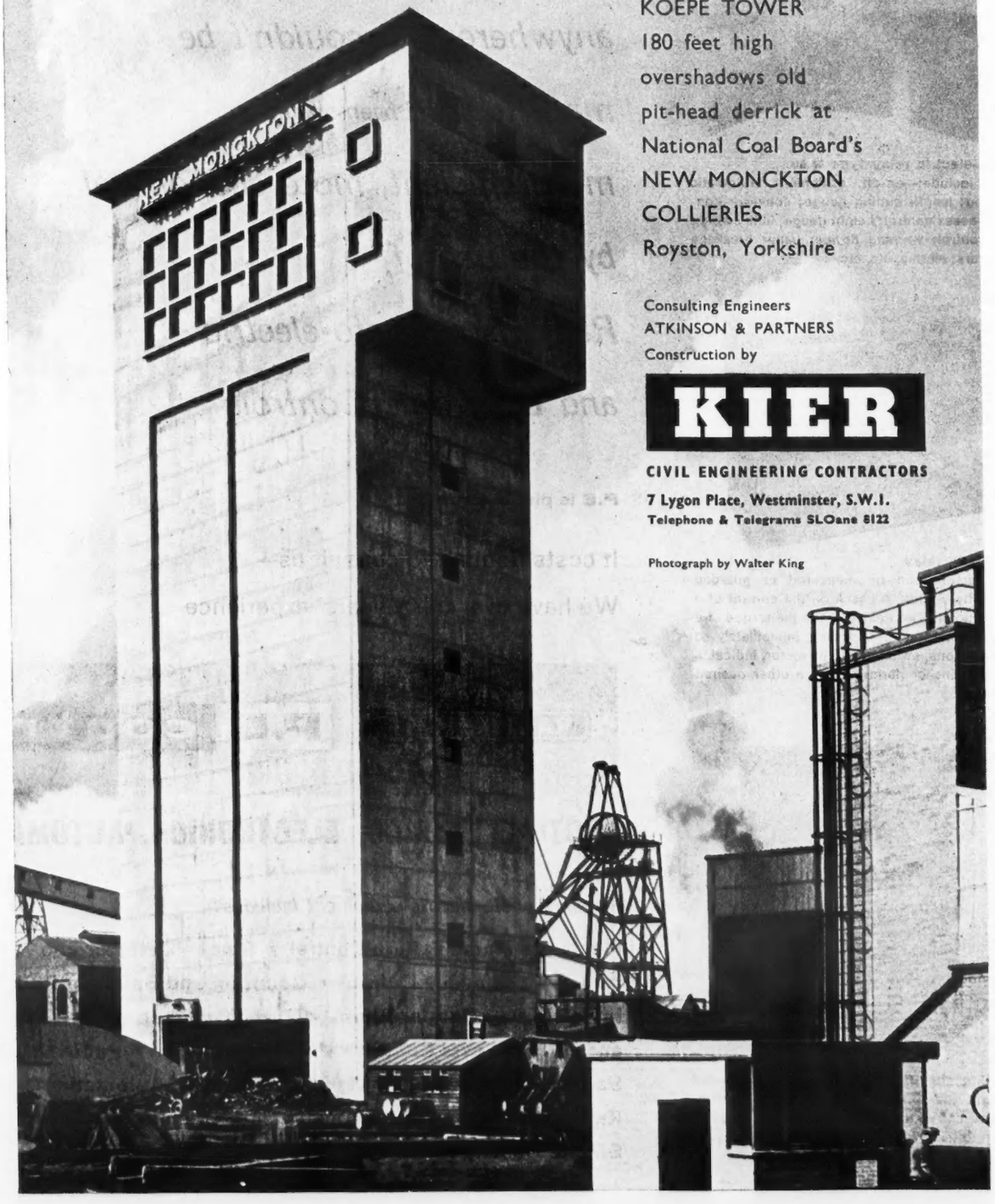

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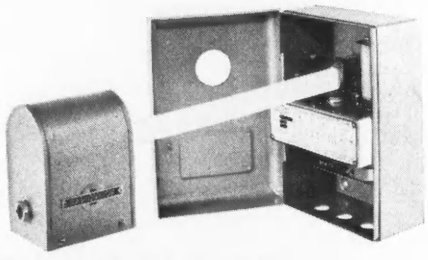

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Uses include:—on-off switching; automatic spraying; length cutting gauge; conveyor control; process control; height gauge; limit switch; loop control; warning device; paper breakage indicators; alarms, etc. etc.

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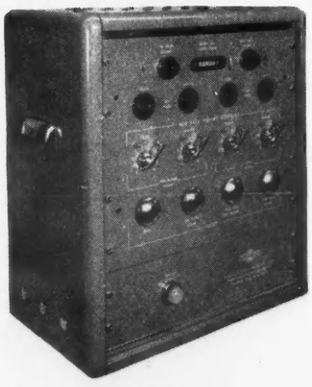
Many factors can be measured or guarded against by keeping a check on the current of a driving motor. The Relay senses the torque of a driving motor and responding immediately to load variations, switches off the motor, indicates the variations or performs some other desired operation.



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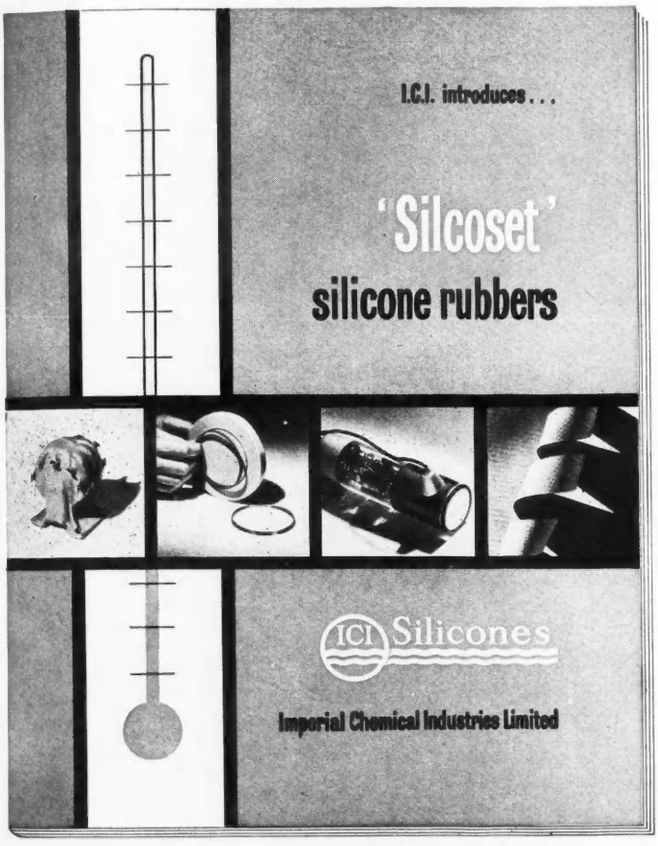

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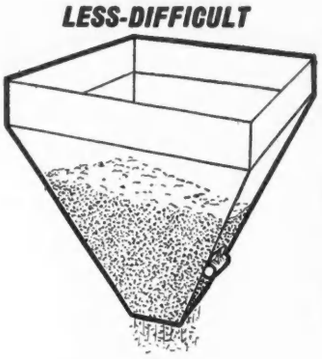
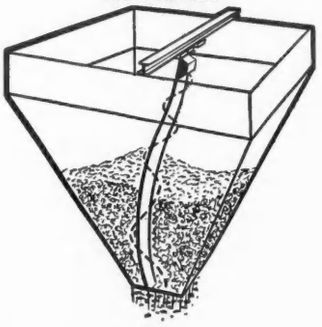
LESS-DIFFICULT



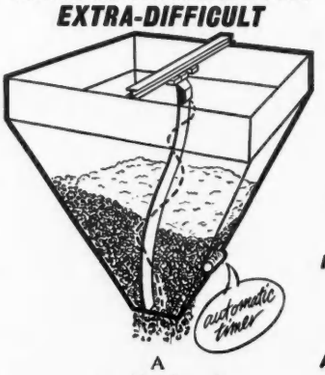
The installation of an external vibrator to a steel hopper.

DIFFICULT



The vibrating reed for application where external vibration is impractical due to structural or other difficulties and if the bunker is made of concrete.

EXTRA-DIFFICULT



A combination of internal and external bunker vibration. Where the external vibrator is timed for 'on and off', the vibration frequency, on slowing down, goes through the natural resonance of the bunker, irrespective of load material contained.

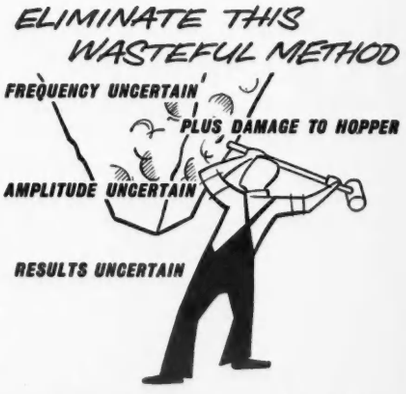
trouble-free bunker discharge

The primitive, inefficient method commonly used for clearing material which sticks in a storage bunker is by applying a sledge hammer to the side of the hopper. This is a form of low frequency, uncontrolled vibration. When vibration is applied at the *correct* frequency, the *correct* amplitude and the *correct* point of application, almost any material can be satisfactorily discharged.

SINEX has the experience with a wide variety of materials and a wide range of hopper designs to recommend how vibration should be applied effectively to solve *your* particular problem.

The three examples illustrated show three different combinations which are typical of many applications, but even these, whilst using the same type of unit, can only be effective if the types of unit themselves are placed in the correct position and have the correct frequencies and amplitudes of vibration to suit the characteristics of the material to be discharged.

It would pay you, therefore, to make use of our experience and to consult us on your particular problem. Send for relevant details and information sheet.



These are some of the many materials which we have handled satisfactorily and ensure trouble-free bunker discharge : Pulverized and small coal, iron-ore, coke, lime, flour, grain, grist, foundry sand, soda ash, cullet, sand, gravel, granite chips and all road stone materials.

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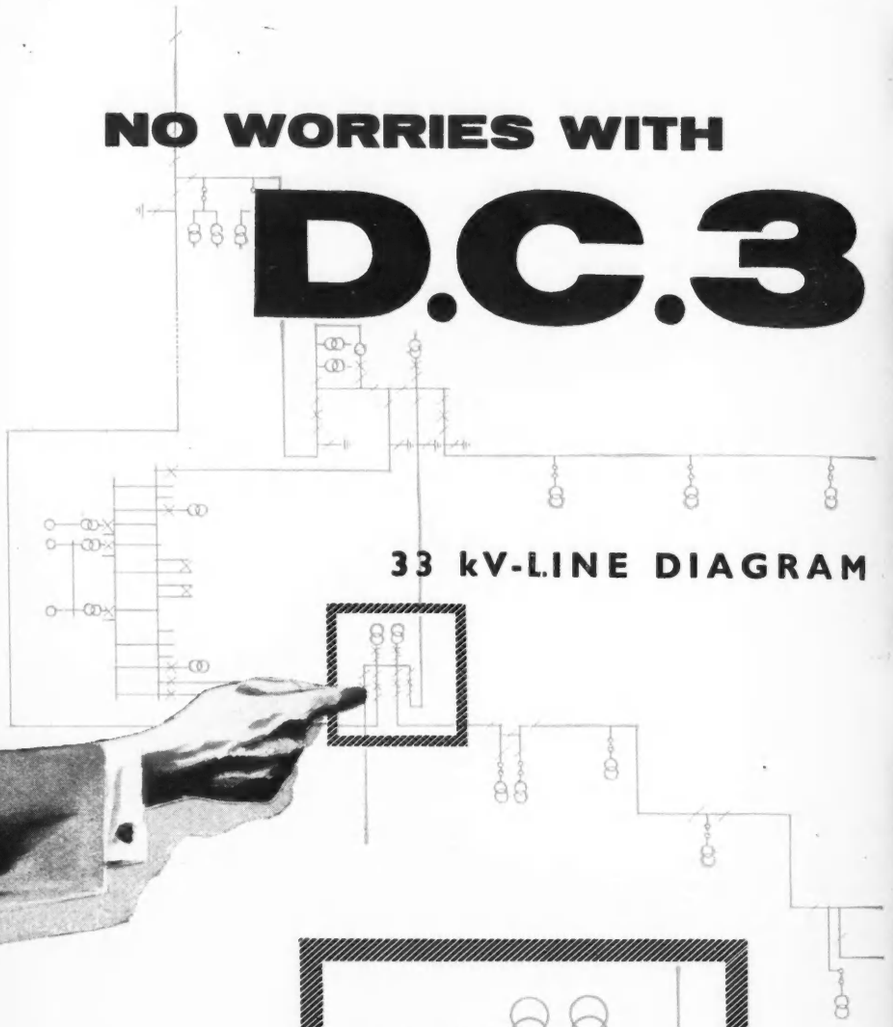

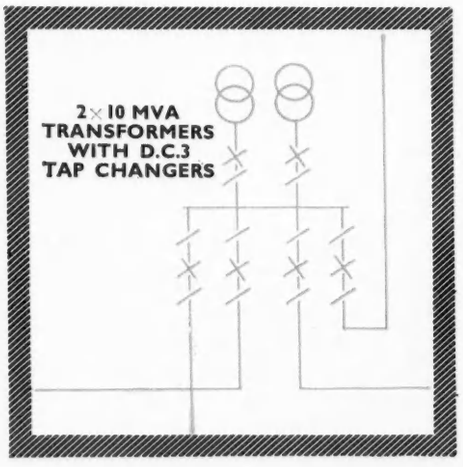

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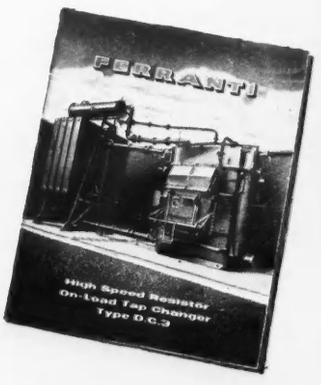
- Arcing contacts will perform more than 200,000 operations at rating equivalent to full load on a 10 MVA transformer.



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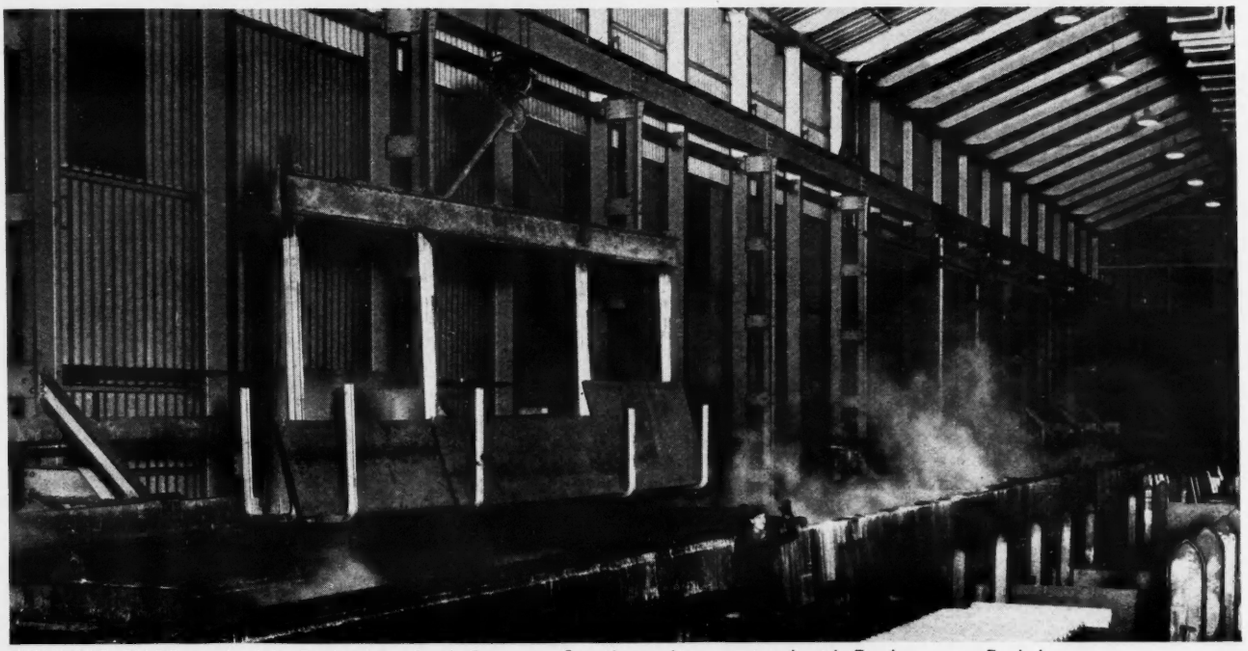

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Photograph by courtesy of Appleby-Frodingham Steel Company (Branch of the United Steel Companies Limited)

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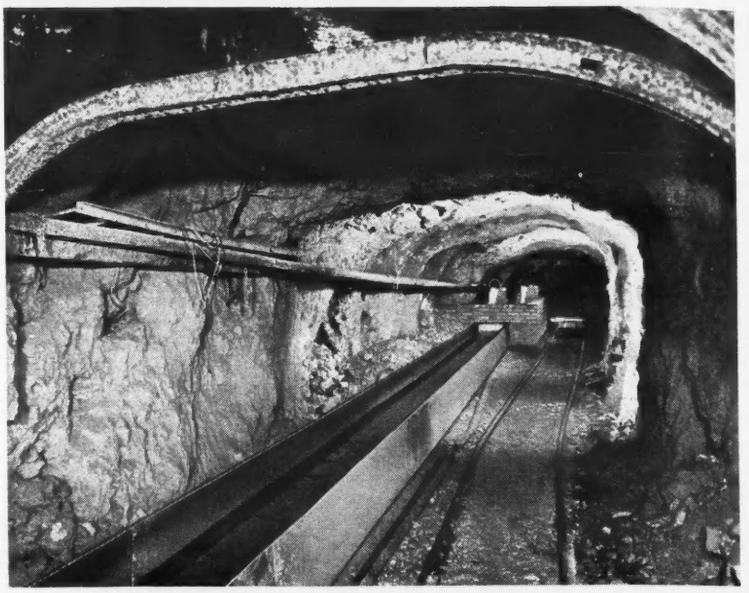
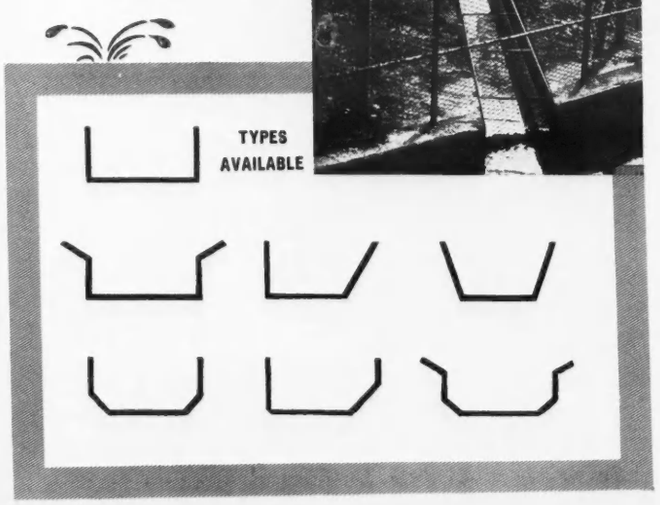


Water pumped from lower level to main sump through Box Gutters at an Iron Ore Mine in Glamorgan. *Below: Continuation towards outfall.*

460 ft. length Box Gutter leads water to nearest stream, preventing seepage to underground workings.



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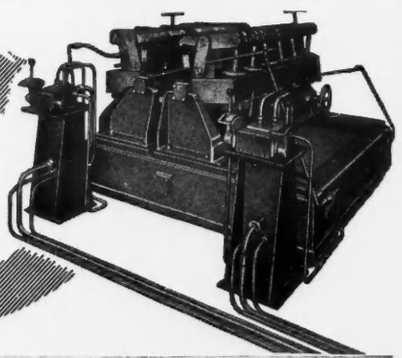
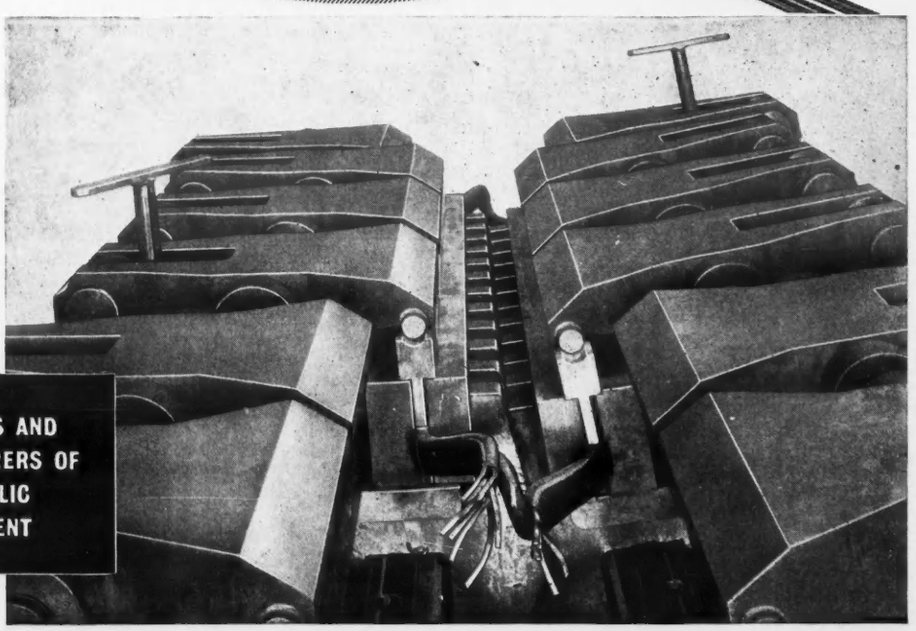


Specially developed for the electrical industry, the press illustrated is one example of the variety of machines we supply to customers' requirements.



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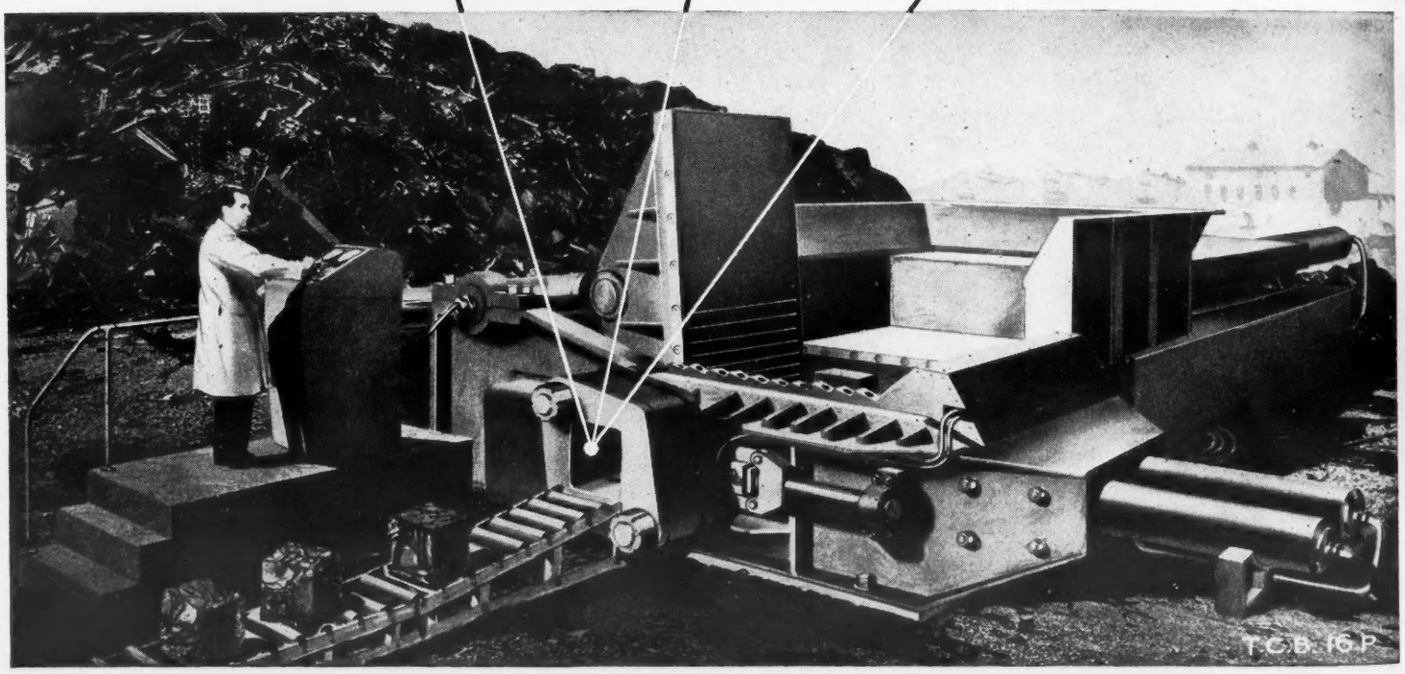

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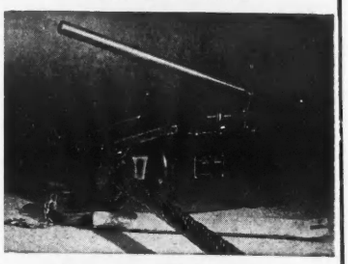

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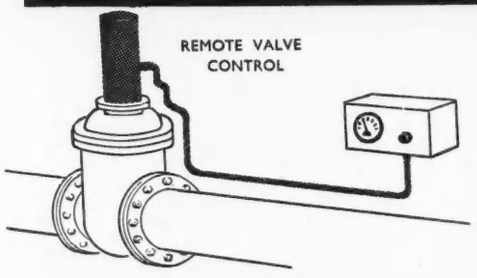

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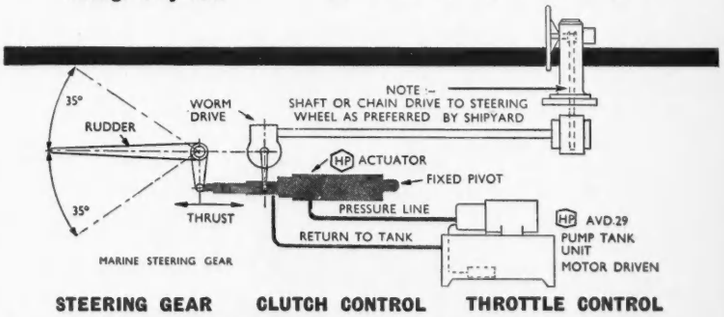

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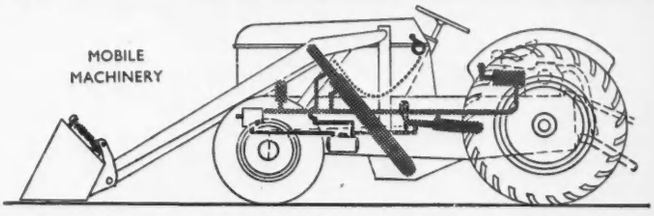

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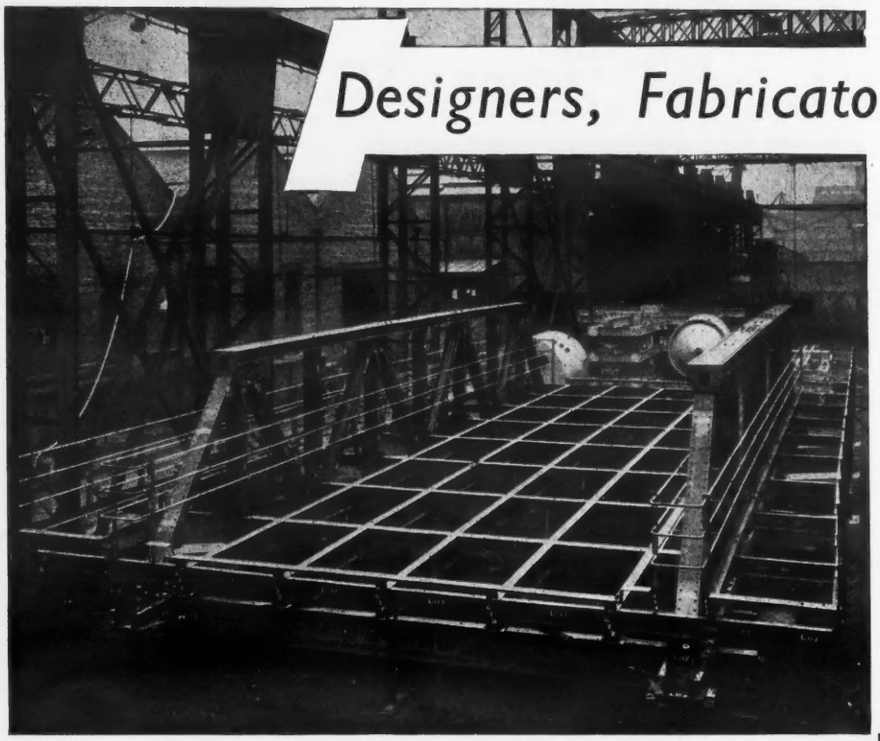

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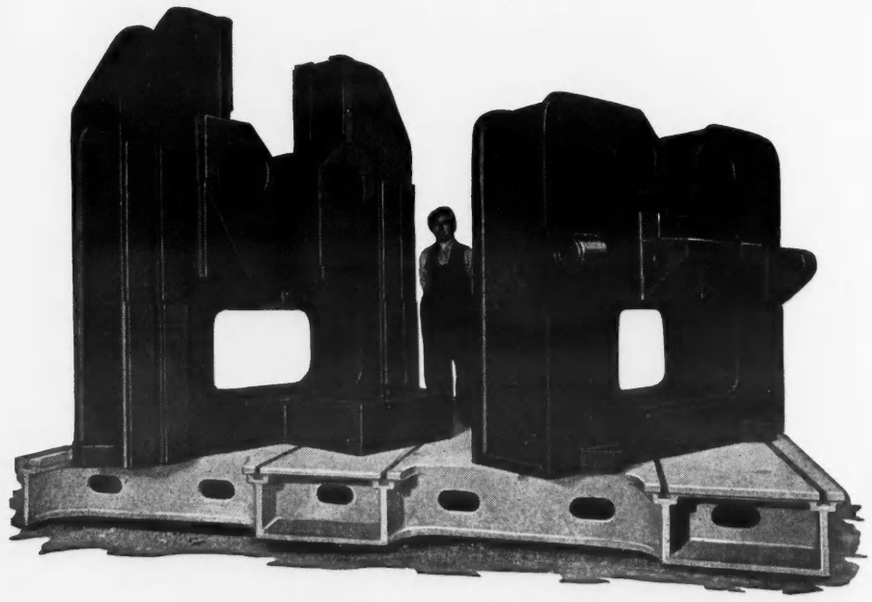

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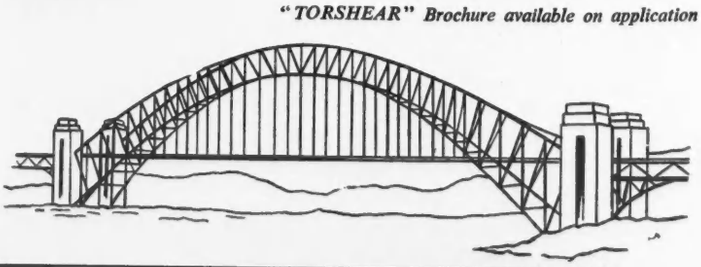

A.P.Newall
AND COMPANY LIMITED
POSSILPARK · GLASGOW N.2.

ALSO AT LONDON AND BIRMINGHAM

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CLASSIFIED ADVERTISEMENTS

PUBLIC APPOINTMENTS · SITUATIONS VACANT · TENDERS · EDUCATIONAL · BUSINESSES and PREMISES · BUSINESS OPPORTUNITIES PATENTS · MISCELLANEOUS · AGENCIES · DIRECTORS · PARTNERSHIPS

Lineage Rate. 4/6 per line of approximately 6 words. Minimum 18/-. **Inch Rate.** 54/- per single column inch and pro rata. 12 lines to 1 inch.

There are reduced rates (i.e., not on a pro rata basis) for advertisements of ¼-page (12 column inches) and upwards, e.g., ¼-page £29 10s. ½-page £54. Full page £100.

FOR SALE · MACHINERY, etc., WANTED · AUCTION SALES · SITUATIONS WANTED · SUB-CONTRACTING · DESIGN SERVICES · FOR HIRE

Lineage Rate. 4/- per line of approximately 6 words. Minimum 16/-. **Inch Rate.** 48/- per single column inch and pro rata. 12 lines to 1 inch.

There are reduced rates (i.e., not on a pro rata basis) for advertisements of ¼-page (12 column inches) and upwards, e.g., ¼-page £25 10s. ½-page £48. Full page £90.

Run-On and Semi-Displayed Styles. Both these styles are available for single column width advertisements of any depth up to 12 inches.

Displayed and Illustrated Styles. The minimum size for a Displayed advertisement is 3 inches single column, for an illustrated advertisement it is a ¼-page (12 column inches). Thereafter the sizes for both progress in steps 3 inches deep across 1, 2, 3 or 4 columns.

Use of Box Number. 2/– which includes forwarding of replies.

Copy Dates. Tuesday for publication on Friday of the same week. If proofs are wanted, copy is required on Thursday for publication on Friday of the following week.

Advertisements for publication should be addressed to:—**Classified Advertisement Dept., "THE ENGINEER," 28 Essex Street, Strand, London, W.C.2**

Urgent advertisements may be telephoned to CENtral 6565.

PUBLIC APPOINTMENTS

ROYAL MILITARY COLLEGE OF SCIENCE

SHRIVENHAM

ASSOCIATE PROFESSORSHIPS

Three pensionable posts for men of high standing in their subjects as follows :

(a) in the Department of MATHEMATICS and PHYSICS with special interests in Ballistics ;

(b) in the Department of CIVIL and MECHANICAL ENGINEERING with special interests in Applied Mechanics, including Fluid Mechanics ;

(c) in the Department of CIVIL and MECHANICAL ENGINEERING with special interests in Applied Thermodynamics.

The successful candidates will be expected to undertake and lead research in their own fields and to teach at degree and post-graduate level. Salary £2300 to £2600 (under review). Starting pay may be above minimum. Existing superannuation rights preserved where possible. Secondment from, or transfer to, Scientific Civil Service possible. The College is residential ; rented houses available for married men, and quarters for single men. Write Civil Service Commission, 17 North Audley Street, London, W.1, for further particulars and application form quoting S/5156/60. Closing date 5th September, 1960. E5372

NIGERIAN COLLEGE OF ARTS, SCIENCE AND TECHNOLOGY

SENIOR TECHNOLOGIST OR A TECHNOLOGIST

Applications are invited for a SENIOR TECHNOLOGIST or a TECHNOLOGIST for the engineering laboratory and workshops for students preparing for University of London B.Sc. (Eng.) in Special Relationship.

Qualifications : H.N.C. or O.N.C. or appropriate City and Guilds qualification in Telecommunications. Good experience on maintenance and construction of electronic equipment and instrument maintenance essential.

Contract Salary Scales : Technologist £756 to £1284 p.a. Senior Technologists £1140 to £1440 p.a., both plus inducement addition of £180 to £300 p.a. for overseas appointees and gratuity at £25 or £37 10s. for each completed 3 months' residential service. Entry point according to qualifications and experience.

Partly furnished houses at one-twelfth basic salary rental. Tours 15-18 months. Children's U.K. maintenance grant up to £150 p.a. and passages assistance.

Applications (8 copies) giving age, qualifications, experience and names of 3 referees should be sent to The Council for Overseas Colleges, 12, Lincoln's Inn Fields, London, W.C.2 by 29th July, 1960. E5386

UNIVERSITY OF LIVERPOOL

TWO POSTS OF LECTURER IN THE DEPARTMENT OF BUILDING SCIENCE

Applications are invited for TWO POSTS of LECTURER in the DEPARTMENT OF BUILDING SCIENCE. The initial salary for one post will be within the range £1050 to £1350 per annum, and for the other post within the range £1050 to £1625 per annum, according to age, qualifications and experience.

Applications, stating age, academic qualifications and experience, together with the names of three referees, quoting ref. CV/En should be received not later than 30 July, 1960, by the Registrar, from whom further particulars of the conditions of appointment may be obtained. E5353

QUEEN MARY COLLEGE

(UNIVERSITY OF LONDON)

LECTURER IN MECHANICAL ENGINEERING

Applications are invited for the post of LECTURER IN MECHANICAL ENGINEERING tenable 1st October, 1960. Salary scale £1050 by £50 to £1400 by £75 to £1550 (efficiency bar) by £75 to £1850, plus London Allowance £60. F.S.S.U. participation and family allowance of £50 for each child. Initial salary according to qualifications and experience. Application forms, obtainable from the Registrar, Queen Mary College, Mile End Road, E.1, to be returned by 8th August. E5400

PUBLIC APPOINTMENTS

NOTTINGHAM AND DISTRICT TECHNICAL COLLEGE

BURTON STREET, NOTTINGHAM

Principal : D. A. R. CLARK, M.Sc.(Tech.), M.I.Mech.E.

RESEARCH ASSOCIATESHIP IN MECHANICAL ENGINEERING

Applications are invited for a full-time RESEARCH ASSOCIATESHIP IN MECHANICAL ENGINEERING.

This research post offers considerable scope. Applicants should possess an engineering degree of a British University, and the person appointed will be encouraged to prepare for a higher degree if appropriate.

Salary : £650 by £50 to £750 per annum.

Further particulars and form of application may be obtained from the Principal, to whom completed forms should be returned not later than 10th August, 1960. E5412

EAST SURREY WATER COMPANY

ENGINEERING ASSISTANT

The Company requires the services of a qualified CIVIL ENGINEERING ASSISTANT on the permanent staff to assist initially with a £750,000 capital works programme. The Company at present supplies an area of 280 square miles with 15 m.g.d.

Housing accommodation will be provided, if required, and removal expenses paid.

Starting salary will be between £1000 and £1250 per annum, according to experience, with pension rights.

Applications, giving details of age, education, qualifications and experience, should be received by the undersigned by the 1st August, 1960.

G. M. SWALES,
B.Eng., A.M.I.C.E., M.I.W.E.,
Chief Engineer.

London Road,
Redhill, Surrey. E5360

RIVER DOVE WATER BOARD

ASSISTANT CIVIL ENGINEERS

Qualified engineers required urgently to assist in completing the first stage of a £5 million project, including a rolled fill dam and hydro-generation plant, and also for the design and construction of the second stage, including pumping plant, water tower and a 10 mg reservoir. Applicants should preferably have some experience in designing in reinforced concrete and have waterworks experience.

Salaries offered within the A.P.T. Scale IV : £1065 to £1220. General conditions of Service will apply, the posts are superannuable and subject to medical examination.

Applications should be sent to Engineer and Chief Executive, River Dove Water Board, Bowling Green Street, Leicester, by Friday, 29th July, 1960. E5409

DEPARTMENT OF MAIN ROADS

NEW SOUTH WALES AUSTRALIA

CIVIL ENGINEERS

Applications are invited from graduates (or undergraduates in their final year) in Civil Engineering of a recognised British or Irish University for appointment to the staff of the Department of Main Roads, New South Wales, the State Road Authority for construction of roads and bridges.

On appointment, applicants may be engaged at the Department's Head Office, Sydney, on the design of reinforced concrete and steel bridges, or on main road construction and maintenance either in the Metropolitan Area or the country.

Commencing salary according to qualifications and experience will be within the range £A1185 to £A1410 per annum, with annual progression, subject to technical competence to £A2095 per annum. Appointees will be eligible to contribute to the State Superannuation Fund after six months.

Appointee's full fare from England to Australia will be met by the Department, subject to a three years' service guarantee bond being completed. Appointment will be subject to passing a medical examination and preference will be given to applicants not more than 30 years of age.

Applications should be made on forms obtainable from the Agent General for New South Wales, 56, Strand, London, W.C.2. E5396

PUBLIC APPOINTMENTS

SOUTH WEST METROPOLITAN HOSPITAL REGION

HORTON HOSPITAL, EPSOM

APPOINTMENTS

APPOINTMENT OF SUPERINTENDENT ENGINEER

Applications are invited for the post of Superintendent Engineer. The person appointed will be directly in charge of the engineering services of the Hospital (1690 beds) and will be responsible for their efficient operation. He will also be in charge of a newly erected water-tube boiler plant of capacity 160,000 lbs of steam per hour, oil-fired and serving in addition to Horton Hospital, four other Hospitals on the Estate.

Candidates must possess one or more of the following qualifications or equivalent approved by the Ministry of Health.

Ministry of Transport and Civil Aviation Extra First Class Certificate of Competency in Marine Engineering.

*Higher National Diploma in Mechanical Engineering or in Electrical Engineering.

*Higher National Certificate in Mechanical Engineering or in Electrical Engineering.

*Diploma in Mechanical Engineering or in Electrical Engineering of a Technical College recognised for the award of the Higher National Certificates.

*(The Mechanical Engineering Certificate or Diploma must be endorsed for electro-technology, and Heat Engines must have been taken as a subject at Ordinary (SIII) level. The Electrical Engineering Certificate or Diploma must include, or be endorsed for, Applied Mechanics and Heat Engines at ordinary (SIII) level.)

Practical experience in Hospital engineering is desirable. Salary scale : £1420 by £45 (4) to £1600, plus £50 London Weighting.

A small house will be available at an annual rental of £55 13s. 6d. plus rates.

APPOINTMENT OF DEPUTY SUPERINTENDENT ENGINEER

Applications are also invited for the appointment of Deputy Superintendent Engineer who would be responsible to the Superintendent Engineer in connection with his duties relating to the Engineering Services of Horton Hospital and to the new central boiler house. Candidates should preferably hold one of the higher qualifications referred to above under Superintendent Engineer or one of the following or its equivalent :-

Ministry of Transport and Civil Aviation (ex Board of Trade) First Class Certificate of Competency in Marine Engineering.

Ministry of Transport and Civil Aviation Certificate of Service as First Class Engineer.

City and Guilds full Technological Certificate in Plant Engineering (First Class).

Salary scale : £940 by £30 (2) by £35 (2) to £1070, plus London Weighting £40 to £50. No residential accommodation available.

Whitley Council Conditions of Service apply to both appointments which are superannuable.

New entrants to the service will be required to pass a medical examination.

Applicants may, if they wish, visit the hospital by arrangement with the Secretary.

Applications stating age, qualifications, experience and the names of three referees, should be sent to The Secretary, Horton Hospital Management Committee, Horton Hospital, Epsom, Surrey, within 7 days of appearance of this advertisement E5408

SHEFFIELD REGIONAL HOSPITAL BOARD

AREA ENGINEER

Applications are invited from Engineers, holding A.M.I.Mech.E., and experienced in designing Heating and Ventilating Installations, for superannuable post of AREA ENGINEER on the Regional Engineer's staff. Salary scale £1665 to £2035. Mileage allowance for use of officer's own car on official business. Duties include responsibility for an engineering design team and liaison with consulting engineers engaged on all engineering services in over 80 hospitals in one of three areas controlled by the Board.

The Area Engineer will have ample opportunity for exercising individual responsibility, creative thought and work, and the expression of personality. The Board's headquarters have a congenial atmosphere and are situated in pleasant surroundings and first class residential suburb of the City. Applications, stating age, full details of education, training, qualifications, career, &c., to be forwarded to the Secretary, Sheffield Regional Hospital Board, Fulwood House, Sheffield, 10, not later than 12th August, 1960. E5365

PUBLIC APPOINTMENTS

SOUTH WEST METROPOLITAN REGIONAL HOSPITAL BOARD

REGIONAL ENGINEER'S DEPARTMENT

ENGINEERING GENERAL GRADE

Applications are invited for appointments on the permanent staff of the Board generally in accordance with the Whitley Council conditions of service.

The Board is undertaking a considerable programme of hospital development and the persons appointed will be engaged on varied and interesting work.

ENGINEERING GENERAL GRADE

Applicants should be (i) Corporate Members of the Institution of Mechanical Engineers and experienced in the preparation of specifications, drawings and estimates for large engineering installations in hospitals and large public buildings, or (ii) Corporate Members of the Institution of Heating and Ventilating, or (iii) have served a recognised engineering apprenticeship and be Graduate Members of the Institution of Mechanical Engineers, having passed " A " and " B " of the Associate Membership examination, or hold exempting qualifications. Sound experience of design of mechanical services of large buildings required. Drawing Office and Estimating experience an advantage.

Salary scale : £910 by £35 (1) by £40 (2) by £45 (5) by £50 (7) to £1600 p.a. Bar at £1205 for graduate members and at £1400 for Corporate members of the Institution of Heating and Ventilating. Corporate Members of the Institution of Mechanical Engineers commencing salary between £1160 p.a. and £1300 p.a. London Weighting allowance of £40 to £50 payable in addition.

Applications stating age, qualifications, experience, present appointment and salary, together with the names and addresses of three referees, should be sent to the undersigned at 40, Eastbourne Terrace, London, W.2, by not later than 25th July.

E. G. BRAITHWAITE,
E5402 Secretary.

BUILDING RESEARCH STATION

GARSTON, WATFORD, HERTS

ELECTRICAL ENGINEER

ELECTRICAL ENGINEER, Basic Grade Professional level, required at Building Research Station, (D.S.I.R.), Garston, Watford, Herts., for following duties : (a) Research connected with electrical service installations in all types of building. (b) Study of methods for electrification of plant and equipment used on building sites including control systems. (c) Development of methods of measurement or data recording by electrical means in connection with building operations or processes. Qualifications: Candidates should be Corporate members of I.E.E., or if under 28, Graduate Members. Honours degree or Dip.Tech. desirable, research or development or electronics experience an advantage. Starting salary in age range 25-34 ; £780 to £1065. Maximum £1220. Forms from Ministry of Labour, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting D.104/OA. Closing date 5th August, 1960. E5392

BOROUGH OF SWINDON

GRADUATE ASSISTANT ENGINEERS

Applications are invited for the appointment of GRADUATE ASSISTANT ENGINEERS in the Borough Engineer's Department.

Applicants should either already hold a Degree in Civil or Municipal Engineering, or expect to obtain one at this summer's examinations.

Swindon is expanding very rapidly to accommodate overspill population from London, and successful candidates would have excellent opportunities to obtain a wide practical experience in the design and construction of the engineering works about to commence for the development of a square mile of open country for industrial and residential purposes. These include main roads and roundabouts ; sewage pumping stations and rising mains, large surface water sewers, storage lagoons, and stream improvements ; as well as normal road and sewer works for estate development.

The salary will be on A.P.T. Grade II (£765 to £880). A five-day week is in operation. Housing accommodation will be offered to married candidates from other areas, and assistance towards removal expenses will be granted.

Application forms, obtainable from the Town Clerk, Civic Offices, Swindon, must be completed and submitted by Friday, 29th July, 1960. E5320

Classified Advts. continued on page 112

TENDERS

INDIA STORE DEPARTMENT

The office of the Director General, India Store Department, Government Building, Bromyard Avenue, Acton, W.3, invites TENDERS for the following :

(a) ONE SECTION ROLLING MACHINE, power-operated, ten stage multispindle machine. Max. capacity 12 gauge 30ft./45ft. per minute feed.
(b) FIVE 6-SPINDLE AUTOMATICS, 1¼in. and 2¼in. max. capacity. Tooled to produce components to drgs.
(c) GUN TUBE REAMING MACHINE :
Max. length of workpiece = 10ft.
Bore through spindle = 7in.
Swing over bed = 22½in. max.
Similar to SIG Type " A" 50/3 max.

Specifications, &c., can be obtained from The Co-ordination Branch, India Store Department, Government Building, Bromyard Avenue, Acton, W.3, at a cost of 10 shillings, per Tender enquiry and is not refundable. Tenders are to be returned to the above address by Thursday, 18th August, 1960.

Specimen copy of the above enquiries can be seen at Engineering Branch, India Store Department, under the following references :
(a) 2830/59/48/SSB/ENG.3.
(b) 2002/60/SSB/ENG.3.
(c) 2004/60/SSB/ENG.3. E5381

INDIA STORE DEPARTMENT

The office of the Director General, India Store Department, Government Buildings, Bromyard Avenue, Acton, W.3, invites TENDERS for the following :

(a) THREE LATHES for MACHINING SHELLS, 50mm. to 110mm. dia., 457mm. long. Similar to Max. Muller Model P.F.S. 300/750in. and THREE SHELL LATHES, for internal blending, 50–110mm. dia. by 457mm. long. Similar to UTITA Model T6V.
(b) COMBINATION TURRET LATHE, similar to Herbert No. 9. Hole in spindle 102mm. Swing over bed covers 572mm.
(c) CENTRE LATHE, 16in. Centres by 40ft. bed with hydro copying.

Specifications, &c., can be obtained from The Co-ordination Branch, India Store Department, Government Building, Bromyard Avenue, Acton, W.3, at a cost of 10 shillings per Tender enquiry, and is not refundable. Tenders are to be returned to the above address by Thursday, 25th August, 1960.

Specimen copy of the above enquiries can be seen at Engineering Branch, India Store Department, under the following references :
(a) 2049/59/SSB/ENG.3.
(b) 2008/60/SSB/ENG.3.
(c) 2013/60/SSB/ENG.3. E5382

WATER COMMISSION

KINGSTON, JAMAICA

FINANCE AND CONSTRUCTION OF WATER SUPPLY SCHEMES

1. Experienced firms of Civil Engineering Contractors are invited to register their names as interested in ARRANGING the FINANCE FOR, and the CONSTRUCTION of, works to augment the water supply of Kingston.

2. The schemes are at present being planned and are expected to comprise :
(a) Either an Earth or a Concrete Dam.
(b) Intake Weirs, Aqueducts and Tunnels.
(c) Pumping Stations, Rising Mains and Gravity Pipelines.
(d) Treatment Works and Service Reservoirs.

3. The estimated cost of these works is £4 million.

4. Construction of the pumping stations and pipelines will probably start early in 1961, and of the other works (which account for the greater part of the estimate) about one year later.

5. It is proposed that Tenders for the construction of the works shall be valued on the basis of unit prices in detailed bills of quantities and the value of the works as constructed, by re-measurement of the actual quantities of work executed. The Conditions of Contract will agree in general with the Oversees Conditions of Contract prepared jointly by the Association of Consulting Engineers and the Export Group for the Constructional Industries.

6. In their letter requesting registration, firms of Contractors should state the maximum period over which repayment can be spread and the interest charges to be made.

7. Contractors should set out briefly particulars of similar works on which they have been engaged.

8. From the applications received a short list will be prepared of the Contractors to whom the Contract Documents will be issued. The final selection of a Contractor to undertake the construction works will be made on the basis of the tenders submitted, the financial terms offered, and the experience of the firm of Contractors. The Commission reserve the right to make no award or to curtail the amount of work awarded.

9. Applications for registration should be addressed to :

The Secretary,
The Water Commission,
28-30 Church Street,
Kingston,
Jamaica, West Indies.

and should reach him by 15th August, 1960.

HOWARD HUMPHREYS & SONS,
Victoria Station House, Victoria Street,
London, S.W.1.,
ENGLAND. Consulting Engineers, E5347

EDUCATIONAL

A.M.I.MECH.E., B.SC., City and Guilds, &c. Guarantee Postal Courses for all Exams. and Technical Divisions from Elementary to Degree standard including Automation Techniques. Approximately 95 per cent. successes. 148-page, prospectus, free on request.—B.I.E.T. (Dept. 22), 29, Wright's Lane, London, W.8. E114 E

TENDERS

INDIA SUPPLY MISSION

TENDER NOTICE NO. SE.224

The office of India Supply Mission, 2536, Massachusetts Avenue, N.W. Washington 8, D.C., United States of America, invites TENDERS for the following :

TENDER NOTICE No. SE.224

For the SUPPLY of TWO TRACTOR TRAILER UNITS for payload of 50 metric tons. One unit is required for transport of 75-ton Crawler-Mounted Mobile Crane. Required by Neyveli Lignite Corporation, Madras, India.

Tender documents, etc., relative to the above, can be obtained from the Co-ordination Branch, India Store Department, Bromyard Avenue, Acton, W.3, at a cost of 14 shillings and threepence per Tender, and is not refundable. Tenders are to be returned direct to India Supply Mission, 2536, Massachusetts Avenue, N.W. Washington 8, D.C., United States of America, so as to reach them by the 25th August, 1960.

Specimen copy of the above enquiry can be seen at India Store Department, Vehicles Branch, Bromyard Avenue, Acton, W.3, under the following reference : S.3290/60/HEA/VEH. E5399

INDIA SUPPLY MISSION

TENDER ENQUIRY NO. SE 205

The office of India Supply Mission, 2536, Massachusetts Avenue, N.W. Washington 8, D.C., United States of America, invites TENDERS for the following :

TENDER ENQUIRY No. SE-205

For the SUPPLY of CEMENT MIXTURE TRUCK AND AGITATOR—3 cubic yard capacity—diesel engine powered required by Neyveli Lignite Corporation Ltd., Madras, India.

Tender documents, &c., relative to the above, can be obtained from the Co-ordination Branch, India Store Department, Bromyard Avenue, Acton, W.3, at a cost of 14 shillings and threepence per Tender, and is not refundable. Tenders are to be returned direct to India Supply Mission, 2536, Massachusetts Avenue, N.W. Washington 8, D.C., United States of America, so as to reach them by the 23rd August, 1960.

Specimen copy of the above enquiry can be seen at India Store Department, Vehicles Branch, Bromyard Avenue, Acton, W.3, under the following reference : S.3259/60/HEA/VEH. E5397

INDIA SUPPLY MISSION

TENDER ENQUIRY NO. SE 200

The office of India Supply Mission, 2536, Massachusetts Avenue, N.W. Washington 8, D.C., United States of America, invites TENDERS for the following :

TENDER ENQUIRY No. SE-200

For the SUPPLY of TRACTORS, CRAWLER TRACK TYPE 55 Draw Bar h.p., required by Additional Director of Agriculture, U.P., Lucknow, India.

Tender documents, &c., relative to the above, can be obtained from the Co-ordination Branch, India Store Department, Bromyard Avenue, Acton, W.3, at a cost of 14 shillings and threepence per Tender, and is not refundable. Tenders are to be returned direct to India Supply Mission, 2536, Massachusetts Avenue, N.W. Washington 8, D.C., United States of America, so as to reach them by the 16th August, 1960.

Specimen copy of the above enquiry can be seen at India Store Department, Vehicle Branch, Bromyard Avenue, Acton, W.3, under the following reference : S.3278/60/HEA/VEH. E5398

COUNTY BOROUGH OF SOUTHAMPTON EDUCATION COMMITTEE

COLLEGE OF TECHNOLOGY

Inquiries are invited from Electrical and Mechanical Engineering companies who would be interested in tendering for work in connection with:—

(a) ELECTRICAL MACHINES LABORATORY
(b) STEAM ENGINES LABORATORY

The work involved would be in each case, the preparation of detailed layouts and specifications in co-operation with the specialist teaching staff, undertaking inquiries and obtaining quotations for approved machines, arranging for the purchase and storage of machines pending installation, manufacturing main control boards and subsidiary controls to agreed specifications, and carrying out the complete installation of machines and wiring from main supply points or pipe-runs, as the case may be. The firms tendering may nominate specialist sub-contractors for approval.

The College of Technology buildings are expected to be started this year, and the first stage (Engineering and Science, Administration and Library) should be completed within two years.

Inquiries, with particulars of similar works carried out, should be addressed to Chief Education Officer (Ref. 57/66), Education Department, Civic Centre, Southampton. E5411 A

EDUCATIONAL

LOUGHBOROUGH COLLEGE OF TECHNOLOGY

LEICESTERSHIRE

METALLURGY FOR ENGINEERS AND SCIENTISTS

A full-time one-year residential course in " SELECTED ASPECTS OF METALLURGY FOR ENGINEERING AND SCIENCE GRADUATES " will commence on October 10th. Further information, course content and syllabuses may be obtained on request from the Head of the Applied Science Department. E5376 E

SITUATIONS VACANT

APPLICANTS ARE ADVISED TO SEND COPIES NOT ORIGINALS OF THEIR TESTIMONIALS UNLESS OTHERWISE REQUESTED.

AN ENTIRELY NEW APPOINTMENT being made by the Production Engineering Research Association offers rewarding possibilities to a MECHANICAL or PRODUCTION ENGINEER with a flair for lucid self-expression and close reasoning. Other essential requirements include good technical knowledge of basic production techniques and equipment, and ability to work with minimum of supervision. Send full details of training, experience and present salary to the Secretary, PERA, Melton Mowbray, Leics. E5306 A

AN EXCELLENT OPPORTUNITY

A Senior Executive is required as PERSONAL ASSISTANT to Chairman and Managing Director to assist in expanding a well-established small Engineering Company, London. Applicants must have thorough administrative experience and hold Mechanical or Electrical qualifications on both practical management and design work. The age group desired is 28-35 years. Leading to appointment of responsible position dependent on initiative, drive and hard work. Salary will be commensurate with qualifications and ability.

Applicants are invited to submit a resume of experience, &c., which will be treated in strictest confidence by the Managing Director, personally. All replies will be acknowledged.

Please write to BOX No. E5403, " The Engineer." A

AREA WORKS ENGINEER required. Technical training at least to H.N.C. standard. Chemical Works experience essential. Applicants should be over 26 years of age. Salary according to experience. Pension Scheme.—Apply, stating experience and qualifications to Personnel Manager, Howards of Ilford Limited, Ilford, Essex. E5368 A

DRAUGHTSMAN REQUIRED for Mechanical Engineering Company, Charlton District. Suitable candidate, preferably with H.N.C. or equivalent may be offered original development work.—BOX No. E2940, " The Engineer." A

BROWN AND POLSON LTD.

require an

INSTRUMENT ENGINEER

for design and development work in connection with new chemical process plants, manufacturing starch, glucose and a variety of starch derivatives.

Experience essential on pneumatic and electrical instrumentation systems and associated relay circuits.

Minimum qualification H.N.C., degree preferred ; supervisory experience an advantage. Age 26-35.

Attractive salary and welfare conditions.

Detailed applications should be forwarded to the

PERSONNEL ADVISER,
TRAFFORD PARK,
MANCHESTER, 17.

E5385 A

CHIEF ESTIMATOR

Applications are invited for this Senior Appointment, preferably with experience of Contractors Plant or Plate and Structural Steel work.

Post carries attractive salary for person of experience and ability, together with Membership of the Company's Pension Scheme.

Housing assistance available to suitable applicant.

Apply in writing to the :

General Manager,
MILLARS' MACHINERY CO., LTD.,
Thorley Works,
Bishop's Stortford, Herts.

E5387 A

DESIGN DRAUGHTSMAN required to work on Marine Propulsion Gears. Vacancies at Westminster and also Chesham offices. Permanent, pensionable positions. Good salaries.—Apply in first instance in writing to Technical Manager, Modern Wheel Drive Ltd., Lindo Lodge, Chesham, Bucks. E5391 A

DRAUGHTSMEN are required for interesting work on small electric motors of various conventional and novel designs in the drawing offices at our Islington and St. Albans factories. An apprenticeship or similar sound D.O. experience in mechanical engineering is required, electrical experience an advantage. Interviews in London or St. Albans.—Write in the first case to : Limit Engineering Group Ltd., 64 Essex Road, London, N.1. E2930 A

DRAUGHTSMEN. Versatile Engineering Draughtsmen with general experience are required by a Plastics Manufacturing Company employing approximately 2000, with Engineering Department of 400. The work involved includes machinery design and layout, &c., and is of considerable interest. O.N.C. or H.N.C. desirable A.E.S.D. rates and above. Good transport facilities and working conditions. Contributory Life Assurance/Pension Scheme.—Apply, giving details of training, qualifications, experience, age, and career to date, to Personnel Manager, BX Plastics Ltd., Brantham Works, Nr. Manningtree, Essex. E5356 A

ENGINEERING INSURANCE. Applications are invited from Mechanical Engineers not over 35 years of age, who having served an apprenticeship with Crane and Lift Makers have a sound theoretical and practical knowledge of Cranes, Lifts, Lifting Machines and their maintenance, and are qualified to Higher National Certificate standard, for a vacancy as ENGINEER SURVEYOR based in the Stoke-on-Trent district. The position is permanent, pensionable, with salary scale of £800 rising to £1100 per annum, plus expenses and allowances. —Apply in own handwriting to BOX No. E5373, " The Engineer." A

SITUATIONS VACANT

ENGINEER with wide practical and designing experience of Electric Overhead Cranes required as Shop Manager. Permanent, progressive and pensionable post.—Fred Watkins (Engineering) Ltd., Coleford, Glos. E5390 A

ENGINEERING DRAUGHTSMEN

required by the National Coal Board in London. The vacancies are in the undermentioned Departments.

X.1813/2C. PRODUCTION. Applicants should have a knowledge of mechanisms and mechanical handling equipment and experience of mining machinery would be an advantage. O.N.C. or equivalent qualification is required.

X.1850/2C. CARBONISATION. Experience of structural steel work and layout drawing for coke ovens, chemical or gas plant would be an advantage. O.N.C. or equivalent qualification is required.

Five-day week, 3 weeks paid holiday (present arrangements honoured), Staff Restaurant, Sports and Social Club. Appointments superannuable. Salaries depending on qualifications and experience within £808 to £927.—Write for application form to Staff Dept. (quoting relevant number), N.C.B., Hobart House, London, S.W.1, before 25th July, 1960. E5393 A

EXPERIENCED DESIGN ENGINEERS

required for interesting work in a wide field of heat transfer application with particular emphasis on large and small water tube boilers. The work is interesting and varied. Applicants must have the ability and initiative to design complete units and ancillary equipment. There are several positions to be filled mostly of a senior nature. Salary according to experience and ability. Contributory Pension Fund. Staff dining room. State (in writing) age and experience.

Staff Manager,
FOSTER WHEELER LIMITED,
3, IXWORTH PLACE,
LONDON, S.W.3.

E5326 A

INDUSTRIAL FURNACE CONSTRUCTION COMPANY engaged principally in Iron and Steel Industry on construction of all types of Furnaces require SITE ENGINEERS age 30 to 40 years, and JUNIOR SITE ENGINEERS age 23 to 30 years. Applicants should preferably be qualified engineers with Iron and Steelworks experience, but engineers with sound practical experience will be considered. They should be prepared to travel to sites in United Kingdom as required. These are permanent appointments with participation in Pension Scheme after probationary period. Salary commensurate with qualifications and experience, plus bonus.—Applications giving personal details, qualifications and experience to BOX No. E5362, " The Engineer." A

OPPORTUNITY FOR STRUCTURAL DESIGNER

occurs at old-established works in pleasant country surroundings.

The man appointed will be required to work for a period as Assistant prior to assuming the position of Chief Designer and Estimator in an office which undertakes a variety of structural steelwork.

Applicants should have a sound experience in competitive design of various classes of steelwork including buildings.

A pension scheme is in operation. Three weeks annual holiday.

Write, stating age, experience and salary required to :
THE FAIRFIELD SHIPBUILDING AND ENGINEERING CO., LIMITED,
CHEPSTOW, MON.

E5367 A

PROJECT AND ESTIMATE DRAUGHTSMAN required capable of handling complete Coal, Ash, and Foundry Mechanisation Schemes. Five-day week, three weeks annual holiday, luncheon vouchers. BOX No. E5294, " The Engineer." A

SITE PLANNING AND PROGRESS ENGINEER

A National firm of chemical engineering contractors require a Site Planning and Progress Engineer. Age 25-35. Previous planning experience desirable but not essential. Duties would primarily be on site, but would involve liaison with Head Office. Pension Scheme.—Applications in writing, giving details of age, qualifications and previous experience to BOX No. E5342, " The Engineer." A

SENIOR MECH. DESIGNERS

with experience of small mechanisms required. H.N.C. preferred but not essential. Handwritten applications with full particulars and salary required to BOX No. E5374, " The Engineer." A

SALES ENGINEER, required to promote the sale of a new product which facilitates the erection of steel structures. Experience in the design and erection of structural steelwork and a good knowledge of welding are necessary.—Details of experience and salary required to BOX No. E2891, " The Engineer." A

SITUATIONS VACANT

SERVICES ENGINEER

A textile company of international reputation has a vacancy for a Services Engineer. He will be required to take design responsibility, under the Senior Services Engineer, for Services plant comprising : Steam, high pressure hot water, gas, compressed air, vacuum, spinning, finish and unit cleaning, together with ancillary and special purposes plant.

Applicants should have :

1. Either a Degree or Corporate Membership of the Institution of Mechanical Engineers.
2. At least three years' industrial experience, preferably in a processing industry.
3. A suitable apprenticeship or sea-going training.
4. Preferably some experience of installation work.
5. Approximately 30 years of age.

Salary will be in the approximate range of £1250 to £1800 according to experience. Assistance will be given with removal and other expenses. A Profit Sharing and Contributory Superannuation Schemes pertain.

Applicants are requested to write, quoting Reference 2/E/S/ to
BOX No. E5341, " The Engineer."

A

THE METAL BOX COMPANY LIMITED RESEARCH DEPARTMENT ALPERTON

DESIGNER DRAUGHTSMAN

Applications are invited for the appointment of a designer-draughtsman to take charge of a small drawing office attached to the Research Department of the Metal Box Company Limited at the Alperton laboratories.

The work of this unit is the preparation of working detail drawings for laboratory instruments and test equipment for a wide range of metallic and non-metallic materials and finished products used in the packaging industry, also laboratory scale processing machinery and process control equipment.

Some experience of instrument design is desirable, but the ability to undertake the very varied requirement of the department is of equal importance.

Please apply in writing to : Ref. ALP. 2
THE METAL BOX COMPANY LIMITED,
ADMINISTRATION RESEARCH DEPARTMENT,
Kendal Avenue, Westfields Road, Acton, W.3.

E5401 A

SENIOR MATERIAL HANDLING AND STRUCTURAL ENGINEERING DRAUGHTSMEN, age 25 to 35, required for Design and Detail Work in our Bromley, Kent, and Brighton offices. Salaries over A.E.S.D. rate, commensurate with ability and experience. 37½-hour week, 3 weeks annual holiday (one week granted this year.—Write, stating age and details of experience to John Wilson and Co. (Engrs) Ltd., 30, Widmore Road, Bromley, Kent. E2943 A

SITE ENGINEER required by well-known firm manufacturing a wide range of Mining, Roadmaking and Quarry Plant. Must be capable of directing all aspects of plant erection and controlling labour.—Full details of experience, age, salary required and when available, to BOX No. E5358, " The Engineer." A

STRUCTURAL STEELWORK DETAILING, DRAUGHTSMAN required for expanding Company of Structural Engineers on the South Coast, Knowledge of design preferred but not essential. Very varied and interesting classes of work.—Write BOX No. E2941, " The Engineer." A

TECHNICAL SALES ENGINEER

A leading firm of power transmission engineers proposes in the near future to appoint a Technical Sales Engineer to deal with its interests in the Midlands and South Wales areas. Main qualifications for the appointment are (1) good connections with design and development engineers in these areas, (2) several years' successful selling experience, (3) some training in engineering, preferably power transmission. The appointment is a permanent and superannuated one.—Write BOX No. E5343, " The Engineer."

A

THE MIDLAND TAR DISTILLERS LTD.,

have a vacancy for a STEAM ENGINEER at their Four Ashes Refinery, Near Wolverhampton. Preference will be given to applicants who are technically qualified and who have several years of practical experience.

The duties include responsibility for the efficient management under the Works Engineer of a modern water-tube, oil-fired, boiler plant ; water treatment plant ; and steam turbine generating plant ; for the supply of steam and power to an extensive refinery and chemicals Works.

This is an important key appointment and modern housing accommodation in a pleasant countryside is available to a suitable man. Assistance will be given in meeting removal expenses. A contributory pensions scheme with a generous life assurance is in operation. Salary in accordance with experience and qualifications.—Apply, giving details of age, education, training and experience to Personnel Officer.

E5361 A

SALES ENGINEERS

Continued expansion and promotion within the Organisation has created a number of vacancies in the Field Force of a Leading Machine Tool Importing and Merchanting Company.

It is intended to make Senior appointments in North West (Lancs and Cheshire) and South West England (including West London and Home Counties). Junior posts are vacant in the North West (Yorkshire and Cheshire), and Midland Territories.

Only experienced, well-connected Machine Tool Sales Engineers with first-class record can be considered for Senior Appointments. Junior men must be Apprenticed Engineers up to 30 years of age with sound knowledge of heavy duty machine tools and preferably some selling experience.

Remuneration will be by salary, commission and expenses.

Apply with full details in confidence to Sales Manager, BOX No. E5240, " The Engineer."

A

BICC

MECHANICAL ENGINEERING AND PLANT LAYOUT DRAUGHTSMAN

required, 25/35 years of age, with good engineering background. Five day week. Excellent working conditions. Staff Superannuation Scheme in operation. Write, stating age, experience and qualifications, to:—

The Personnel Officer,
British Insulated Callender's Cables, Ltd.,
Anchor Works, Leigh, Lancs.,

E5407 A

BOOKS and PUBLICATIONS

FLIGHT WITHOUT FORMULAE
By A. C. Kermode *Third Edition*
This readable approach to a technical subject, has sold all over the world to serious students of aeronautics. Now it has been heavily revised. New material has been included on the problems of high-speed flight and a new section added on missiles, satellites and space-ships. Price 21/- net.

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A comprehensive study of the subject, covering the requirements of the new syllabuses of Factory Management and Organisation as developed in the Ministry White Paper on Education and Training for Management. The book is strongly recommended to mechanical engineering and production engineering students and to all who require a systematic preparation for industrial responsibility. **Price 25/- net.**

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GKN THE GUEST KEEN AND NETTLEFOLDS GROUP OF COMPANIES WISH TO MAKE THE FOLLOWING APPOINTMENT AT THEIR GROUP RESEARCH LABORATORY

ELECTRICAL ENGINEER

The Group Research Laboratory at Wolverhampton requires Electrical Engineers to design and develop equipment for the control of automatic processes. This work will involve circuit design, instrumentation and the production of prototype equipment. There are vacancies for:—

1. A graduate engineer, who is a qualified electrical or electronic engineer. He should have experience in modern electronic techniques, including the use of semi-conductors. Preferred age 25-30 (Ref. EE/1).
2. An electrical engineer who is qualified to H.N.C. or equivalent standard, with considerable industrial experience (Ref. EE/2).

Appropriately qualified men are invited to write quoting reference number and giving details of age, qualifications, present salary and career to date to:—

The Recruitment Officer,
G.K.N. Group Research Laboratory,
Birmingham New Road,
Lanesfield, Wolverhampton.

E5354 A

MONSANTO CHEMICALS LIMITED

require

SENIOR PIPING AND LAYOUT DRAUGHTSMEN

with considerable experience in chemical plant design work, for the London Engineering Department. Applicants should be prepared and able to undertake checking and have ability and drive.

Good salaries will be offered to men with the requisite experience in this type of work. Minimum age 28 years. Excellent working conditions; bonus and non contributory pension scheme.

Please send written applications, giving details of age, qualifications and experience to DL145, Personnel Department, Monsanto Chemicals Limited, Monsanto House, 10/18 Victoria Street, London, S.W.1.

E5355 A

Classified Advts. continued on page 114

SITUATIONS VACANT

ENGLISH ELECTRIC, RUGBY

The Diesel Engine Division require several

DETAIL DRAUGHTSMEN

These positions are in the Design Office and applications will be welcome from men with a recognised training and qualifications above O.N.C. standard who have had suitable experience in oil engine manufacture.

Anyone looking for a permanent position with a large Company should write giving full particulars to:— Dept G.P.S. Marconi House, 33/67 Strand, London, W.C.2, quoting reference E1199D.

E5369 A

ELECTRICAL ENGINEER

to be responsible for the operation of all electrical machinery associated with a prototype naval reactor, situated at Dounreay, Caithness, Scotland and to be capable of advising on Power Electrical matters.

Marine experience will be an advantage and candidates should hold a University degree, although exceptional men with H.N.C. would be considered. They should be members of the Institution of Electrical Engineers, or have the necessary theoretical and practical qualifications for corporate membership.

Experience is essential in the operation of heavy A.C. and D.C. rotating machinery, together with associated switch gear, control and distribution systems. Some familiarity with electronic instrumentation is desirable but not essential, and arrangements will be made for the successful candidate to receive adequate specialised training.

A contributory superannuation scheme is in operation, and applications which will be treated as strictly confidential, should give full details of qualifications, present employment, and salary received. All applicants must be of British nationality. Please write in the first instance to:

The Manager, Marine Propulsion,
Research and Development Dept.,
VICKERS ARMSTRONGS (ENGINEERS) LIMITED,
Naval Construction Works, Barrow-in-Furness, Lancashire.

E5379 A

SITUATIONS VACANT

CIVIL ENGINEERING ASSISTANT

who has suitable qualifications and experience is required for planning and design work associated with cement works construction, salaries in accordance with ability and experience; staff profit sharing scheme and pension fund, excellent welfare and canteen facilities, very good working conditions. Interviews by appointment only.

Please apply: Chief Engineer, G. & T. EARLE LIMITED, Wilmington, Hull.

'A member of the Blue Circle Group'

E2939 A

MECHANICAL ENGINEER

required for design, development and adaption of special plant and equipment by well-known Civil Engineering Contractors.

Full technical qualifications essential; experience of Civil Engineering plant would be an advantage.

Attractive post for an Engineer with an inventive and practical mind.

Apply in writing giving details of experience, age, and salary required to

PETER LIND & CO. LTD.,
Romney House, Tufton Street,
London, S.W.1.

E5345 A

SITUATIONS VACANT

MSL *have been retained to advise on the appointment of a*

MANAGER OF SALES ENGINEERING

for a company in the Midlands specialising in the development, design and provisioning of industrial heating equipment. The company, which is at present engaged mainly in the steel industry, is expanding its activities to cover a wider field and is increasing its technical sales division to meet the heavier demand. The appointment carries responsibility to the Director and General Manager for the administration of the technical sales organisation which covers the outside staffs, and the provision of estimates, quotations and specifications.

Candidates must have a sound engineering background, preferably in the steel industry, an intimate knowledge of the trade and several years' experience of technical sales management. A knowledge of instrumentation and electrics would be useful and a degree or other professional qualification or a diploma in fuel technology would be a strong recommendation.

Preferred age 40 to 50. Starting salary, which would be by negotiation, would be approximately £2,500 plus a non-contributory pension scheme and a car.

Please send brief details in confidence, quoting reference G.2517, to M. B. Berks. In no circumstances will a candidate's identity be disclosed to our client unless he gives permission after a confidential interview at which he will be given full details of the appointment.

MANAGEMENT SELECTION LIMITED
17, Stratton Street, London, W.1.

E134 A

CENTRAL ELECTRICITY GENERATING BOARD

DESIGN AND CONSTRUCTION DEPARTMENT

Headquarters, London, S.E.1.

CIVIL ENGINEERING BRANCH Ref. Eng/261

SENIOR ASSISTANT ENGINEER

required in the Civil Engineering Branch concerned with the design and construction of Power Stations and investigations into associated civil engineering matters.

Candidates should have a wide experience in the design and construction of heavy civil engineering works and specialist knowledge of soil mechanics and foundation design. Recent experience in power station design and construction will be an advantage and preference will be given to those who are Corporate Members of the Institution of Civil Engineers.

SALARY WITHIN THE RANGE £1695 to £2240 p.a.

NUCLEAR PLANT DESIGN BRANCH Ref. Eng/262

ASSISTANT ENGINEERS

required in the Nuclear Plant Design Branch responsible for the design and layout of the Reactor Units in the Board's Nuclear Power Stations.

The Branch work closely with the U.K.A.E.A., the Industry and the Board's Project, Research and Operations Groups. It is organised on a functional basis and responsibility is given within the following Sections:— **Reactor Core; Reactor Mechanisms (including Fuel Handling); Pressure Circuit (including Boilers and Gas Circulators); Reactor Materials; Layout (including Shielding and Health Physics); Control and Instrumentation; Performance.**

The range of specialisation is not rigid and candidates are asked to state their interests and to write in sufficient detail, to enable a preliminary assessment to be made. The work is based at the Board's Headquarters in London, but will involve visits to sites, to U.K.A.E.A. Establishments and to Contractors' Offices and Works. Training will be given where necessary.

SALARIES ON SCALES WITHIN THE RANGE £970—£1790 p.a. ACCORDING TO DUTIES AND RESPONSIBILITIES.

Applications stating age, qualifications, experience, present position and salary should be forwarded to the Personnel Officer, 24/30, Holborn, London, E.C.1., by 2nd August. Envelopes should be marked "Confidential," quoting relevant reference number.

E5383 A

MITCHELL ENGINEERING LIMITED

invite applications from

EXPERIENCED SENIOR DRAUGHTSMEN

for the following positions

PETERBOROUGH OFFICE.	Section Leaders.
LONDON OFFICE.	Designers and Detailers for Large Contracts.
LONDON OFFICE.	Project men for the preparation of schemes and Estimates.

Applicants must have had wide experience in all types of Mechanical Handling Equipment for bulk materials in Steelworks, Power Stations, Collieries, etc., and must be capable of working with a minimum of supervision.

Good Salaries will be paid in accordance with experience. Three weeks holiday after one year service. Contributory Pension Scheme available. In the first instance replies must state age, experience and salary required and should be addressed to:—

Room No. 1,
Tavistock House North,
Entrance D,
Tavistock Square,
LONDON W.C.1.

E5410 A

SITUATIONS VACANT

DRAUGHTSMEN

Draughtsmen are required at the Midlands Research Station, Solihull.

The duties are interesting and will include work on the design of pilot and prototype plant associated with the development of new high-pressure processes for the production of town gas.

Candidates should possess at least an O.N.C. certificate in Mechanical Engineering.

The salary for the appointments, which are pensionable and subject to medical examination, will be within the range of £733–£927 per annum.

Applications, stating age, education and experience, should be addressed to the Industrial Relations Officer,

WEST MIDLANDS GAS BOARD,

6, Augustus Road, Edgbaston, Birmingham, 15.

E190 A

SITUATIONS VACANT

CHIEF MECHANICAL ENGINEER

Applications are invited for this senior appointment from qualified Mechanical Engineers who have previous experience in an Aluminium Rolling Mill or similar Industry in a senior capacity.

The successful applicant must have drive and initiative and will form part of a young Management team in a rapidly expanding modern factory which is part of a large industrial group. He will be responsible to the Chief Engineer for all mechanical installations, maintenance and services. He will also be expected to take part in the planning of future developments.

The factory is located in a beautiful rural site within easy reach of the Coast and principal cities.

Applications, giving full details of experience, qualifications, salary, &c., should be marked "Private and Confidential" and addressed to :

The Manager,
REYNOLDS T.I. ALUMINIUM LIMITED,
Rheola Works,
Resolven,
Neath,
Glam.

E5304 A

SITUATIONS VACANT

FISONS FERTILIZERS LIMITED

HARVEST HOUSE, FELIXSTOWE, SUFFOLK

DRAUGHTSMEN

The Company invites applications for the following vacancies at their Head Office in Felixstowe.

CHEMICAL/MECHANICAL PLANT DRAUGHTSMEN

with experience in chemical plant layout and pipe work for a wide field of heavy and fine chemicals, and/or experience in mechanical handling of materials from intake of raw materials through processes to finished products, bagged, packed or in bulk.

Applicants should have had at least 5 years' experience in the above work, have gained O.N.C. at least and be not less than 25 years of age.

CIVIL ENGINEERING DRAUGHTSMAN

with design experience in reinforced concrete, steel frame construction and plant structures. Experience in associated services (roads, drains, etc.) would be an advantage.

Applicants should have had at least 8 years' experience in such work, have gained O.N.C. at least, or Grad.1. Struct.E. and be not less than 28 years of age.

Healthy working conditions, good salaries, five day week, contributory pensions scheme, profit sharing bonus, and assistance with removal expenses.

Applications, with full particulars, to Personnel Manager, (KM4), Fisons Fertilizers Limited, Harvest House, Felixstowe, Suffolk. E5357 A

1. **ENGINEER** age 28-45, to control small staff engaged in Maintenance and Installation work. Progressive outlook. Knowledge of automatic feeding mechanisms, hydraulics and electronics an advantage but not essential. Conscientious man willing to work as one of a team to develop a small Company in South Wales, part of a large Group, with relatively new products. Good prospects for the future.

2. **MECHANICAL ENGINEER SUPERVISOR**
   ELECTRICAL ENGINEER SUPERVISOR
   to control small labour force on shop floor engaged in Plant maintenance and installation in factory developing new processes in South Wales. Good prospects for future.

3. **PROJECT ENGINEER** age 28-35, for work on new projects associated with factory expansion in Midlands. Experience in Mechanical engineering and Building & Services installation. Minimum qualification Higher National Certificate.

Applications giving details of age, education, qualifications, experience and when available, to Sectretary, BOX No. E2942, "The Engineer."

A

FIBREGLASS TRADE MARK

DEPARTMENTAL MANAGER

If you have a degree or higher national certificate in mechanical or electrical engineering, some experience of a continuously operated process, and would like to hold a responsible post in an expanding industry, you are invited to write about yourself to Mr. R. G. Terrell, Production Manager, Fibreglass Limited, St. Helens, Lancashire.

You would be given charge of one of the new crown fibre plants including melting, fiberisation and final processing. Your responsibilities would include day to day running and improvement of processes.

E5394 A

MANAGER

Precision Engineering Division

Applications are invited for the appointment of Manager of the new Precision Engineering Division being set up in the North-West by a prominent and substantial engineering Group. Commencing salary will be the subject of negotiation, but will be not less than £2,500 p.a. plus Company car, pension scheme, etc.

The Divisional Manager will be in complete operational control of the new plant which will be equipped with the most modern machinery and will employ about 300 people in the initial stages. He will be responsible to the Director and General Manager of the parent unit for organisation, lay-out and staffing of the factory and for bringing it into full production. In this task he will have at call extensive technical assistance which will be made available as necessary. Considerable preliminary work on machinery trials, performance figures, draft lay-outs, etc. has already been done and this information will be made available to the Divisional Manager to enable him to formulate his plans with the least possible delay.

The Division is expected to expand rapidly and the opportunities and scope are therefore unusually wide.

Desired qualifications include a degree or professional qualification in mechanical engineering, with considerable experience of administering and controlling a flow-production plant in the automotive or precision engineering industries. A sound knowledge of modern production and management techniques including production planning and control, materials control and work-study is also necessary. Preferred age about 40.

Please write briefly in first instance, quoting Reference No. 780, to :—

AA LTD

ASHLEY ASSOCIATES LTD.
PETER HOUSE, MANCHESTER 1.
RETAINED TO ADVISE ON THIS APPOINTMENT
The strictest confidence will be observed and no details of candidates will be passed to clients without candidates' permission.

E5389 A

SHELL

THE ROYAL DUTCH/SHELL GROUP

offers a career to

MECHANICAL ENGINEERS

in the DESIGN Division

THE HAGUE

HOLLAND

The work is connected with their world-wide activities in the chemical industry.

Honours degree or A.M.I.Mech.E. essential.

Candidates with chemical plant design and/or construction experience would be preferable.

The upper age limit is 34 years, but possibly higher for candidates who have had exceptional experience in this particular field.

Applications in writing with full details of career to :

SHELL INTERNATIONAL CHEMICAL COMPANY LIMITED
Personnel/Recruitment/HME 16
St. Swithin's House,
London, E.C.4.

E5236 A

Classified Advts. continued on page 116

SITUATIONS VACANT

BRITISH CELLOPHANE LIMITED

require a

TECHNICAL SERVICE MANAGER

Applications for the position of Technical Service Manager are invited from men, aged 30/40, having the following qualifications :—

A good Science or Engineering degree.
Successful Management experience.
A balanced interest in current market problems and long term use development.
Enthusiasm, drive and ability to get on well with people.
A practical knowledge of packaging—particularly in respect of Plastic and/or Cellulose films would be an advantage.

The Technical Service Manager will be based on London, W.1., and will be responsible for departmental control of Technical Service Representatives, a Laboratory and a Machine Development Section. He will be required to establish and maintain first class relationship with the Company's customers both in the United Kingdom and overseas by personal contact where necessary. Interviews will take place in London.

Applications to Personnel Officer, British Cellophane Limited, Bridgwater, Somerset. E5370 A

SITUATIONS WANTED

CHARTERED MECHANICAL ENGINEER with Degree, seeks executive position. Age 35. Works Apprenticeship. D.O. training. Experienced Design, Tendering, Sales and Works Management. —BOX No. E2944, "The Engineer." B

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REMPLOY SPONSORSHIP SCHEME

Send for details which show an attractive proposition to manufacturers.

Write to the MANAGING DIRECTOR, REMPLOY LTD., 25-28, BUCKINGHAM GATE, S.W.1, or telephone VICtoria 6621 (12 lines).

E9665 O

MISCELLANEOUS

LUSOL

KILLS RUST AND LUBRICATES

LUSOL The Rust Solvent is invaluable for Dismantling, Repairing and Overhauling Engineering Equipment. Obtainable from your usual Supplier. Enquiries to the manufacturers :—

The Great Eastern Oil Co., Ltd.,

372, Scotland Street, Glasgow. Tel.: South 2207 E184 I

TIME RECORDERS, Sales, Rentals, Service, Telephone Hop 2239.—Time Recorder Supply and Maintenance Co., Ltd., 157-159, Borough High Street, London, S.E.I. E110 I

MOBILE LIFTING SERVICE. Lump Sum or Hire Rate quoted for any lifting work by Lorry-Mounted or Crawler Cranes, any size, any area.—TARSLAG, LTD., Rotherham 78481. E186 I.

FOR HIRE

LATTICE STEEL ERECTION MASTS (light and heavy), 30ft. to 150ft. high, for immediate hire.—Bellman's, 21, Hobart House, Grosvenor Place, S.W.1. E103 K

PATENTS

THE PROPRIETOR of British Patent No. 770,814 for "INTERNAL COMBUSTION ENGINE FOR OPERATION WITHIN THE RANGE OF MEDIUM COMPRESSION RATIOS," desires to enter into negotiations with a firm or firms for the sale of the Patent or for the grant of licences thereunder.—Further particulars may be obtained from Marks and Clerk, 57 and 58, Lincoln's Inn Fields, London, W.C.2. E5359 H

THE PROPRIETOR of British Patent No. 773367 for "AN IMPROVED ELECTRIC SPRAYING PISTOL" desires to enter into negotiations with a firm or firms for the sale of the Patent or for the grant of licences thereunder.—Further particulars may be obtained from Marks and Clerk, 57 and 58, Lincoln's Inn Fields, London, W.C.2. E5378 H

FOR SALE

MEI

C. A. PARSONS STEAM TURBO-ALTERNATOR SET. Passout/Condensing type. 400kW/500kVA, 440 volts, 3-phase, 50 cycles. 190 p.s.i.g. 500 deg. Fah. at S.V. Designed to extract up to 10,000 lbs. steam/hour at 20 p.s.i.g. 280 deg. Fah. Helical Reduction Gear. Surface condenser capacity 5426 lbs/hour. Steam/Air Ejector, Circulating and Extraction pumps. Inspection by appointment.

M.E.I. CO. LTD.,
CYPRUS WORKS,
UPPER VILLIERS STREET,
WOLVERHAMPTON
Tel.: 26354 (4 lines) E5380 G

FOR SALE

TEN R.B. EXCAVATORS fitted 28ft. JIB AND DRAGLINE EQUIPMENT, 5300 Series £525 ; 17,100 Series £1700 ; 18,800 Series £1825. All very good machines.

A.T.O.S. HYDRAULIC EXCAVATOR, new 1958, fit any wheeled tractor with P.T.O. £275.

TRENCHING MACHINES by HOWARD ROTARY HOE, SUPER fitted Perkins L4, new 1958, £1850. STANDARD new 1955, £925.

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August 16	**Miscellaneous stores.**	**M.O.A. Storage Depot, Ruddington, Notts.**	**WALKER, WALTON & HANSON, (Dept. L), Byard Lane, Bridlesmith Gate, Nottingham. (Tel.: 54272).**
August 23	**Miscellaneous stores.**	**Central Ordnance Depot, Didcot, Berks.**	**SIMMONS & SONS, (Dept. L), 12, Station Road, Reading, Berks. (Tel.: 54025).**
September 1	**Vehicles, machine tools and miscellaneous stores.**	**M.O.A. Storage Depot, Bowhouse, Hurlford, Nr. Kilmarnock, Ayrshire.**	**DIXON & WALLACE Ltd., (Dept. L), Bank Buildings, Graham Square, Glasgow, E.1. (Tel.: Bridgeton 2447/9).**
September 6–7	**Machine tools and miscellaneous stores.**	**M.O.A. Storage Depot, Royal Arsenal, Woolwich, London, S.E.18.**	**FULLER, HORSEY, SONS & CASSELL (Dept. L), 10, Lloyd's Avenue, London, E.C.3. (Tel.: Royal 4861).**
September 13	**Miscellaneous stores.**	**No. 1 E.S.D., Long Marston, Nr. Stratford-on-Avon, Warwicks. (Sale at the Hippodrome, Stratford-on-Avon).**	**LOCKE & ENGLAND, (Dept. L), 166, Parade, Leamington Spa, Warwicks. (Tel.: 2833).**
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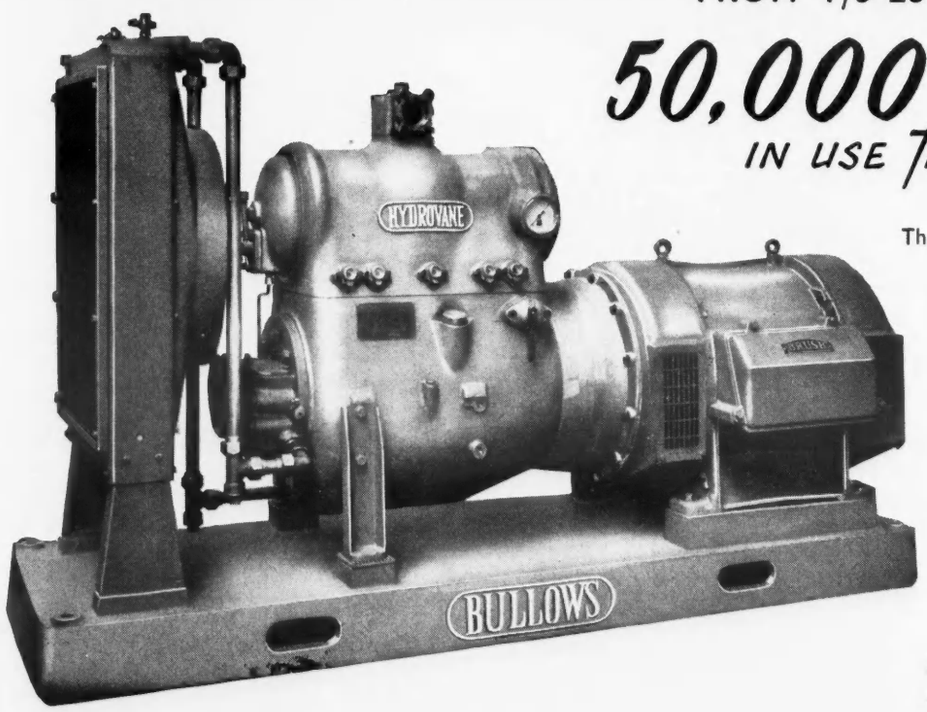

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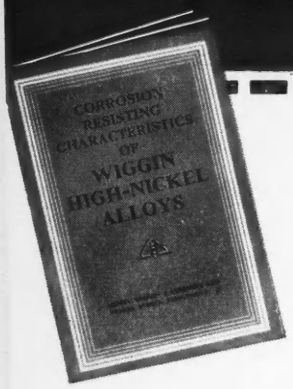

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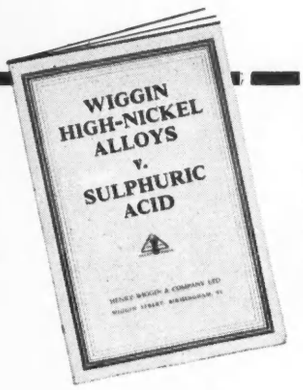

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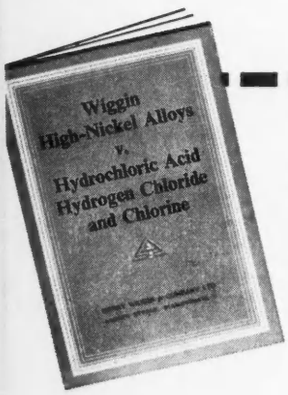

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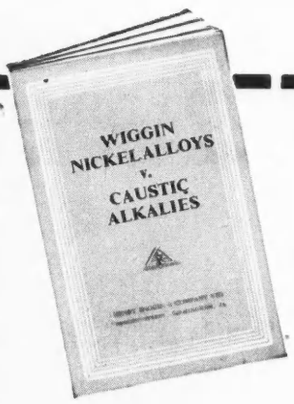

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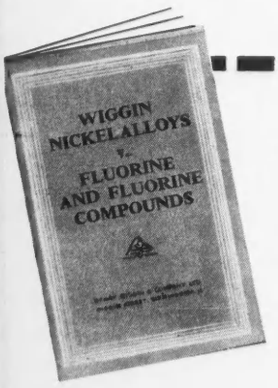

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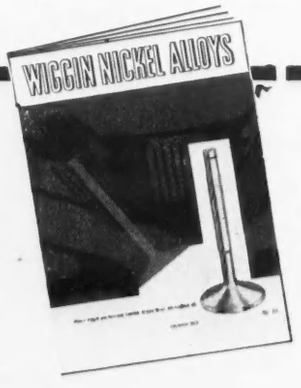

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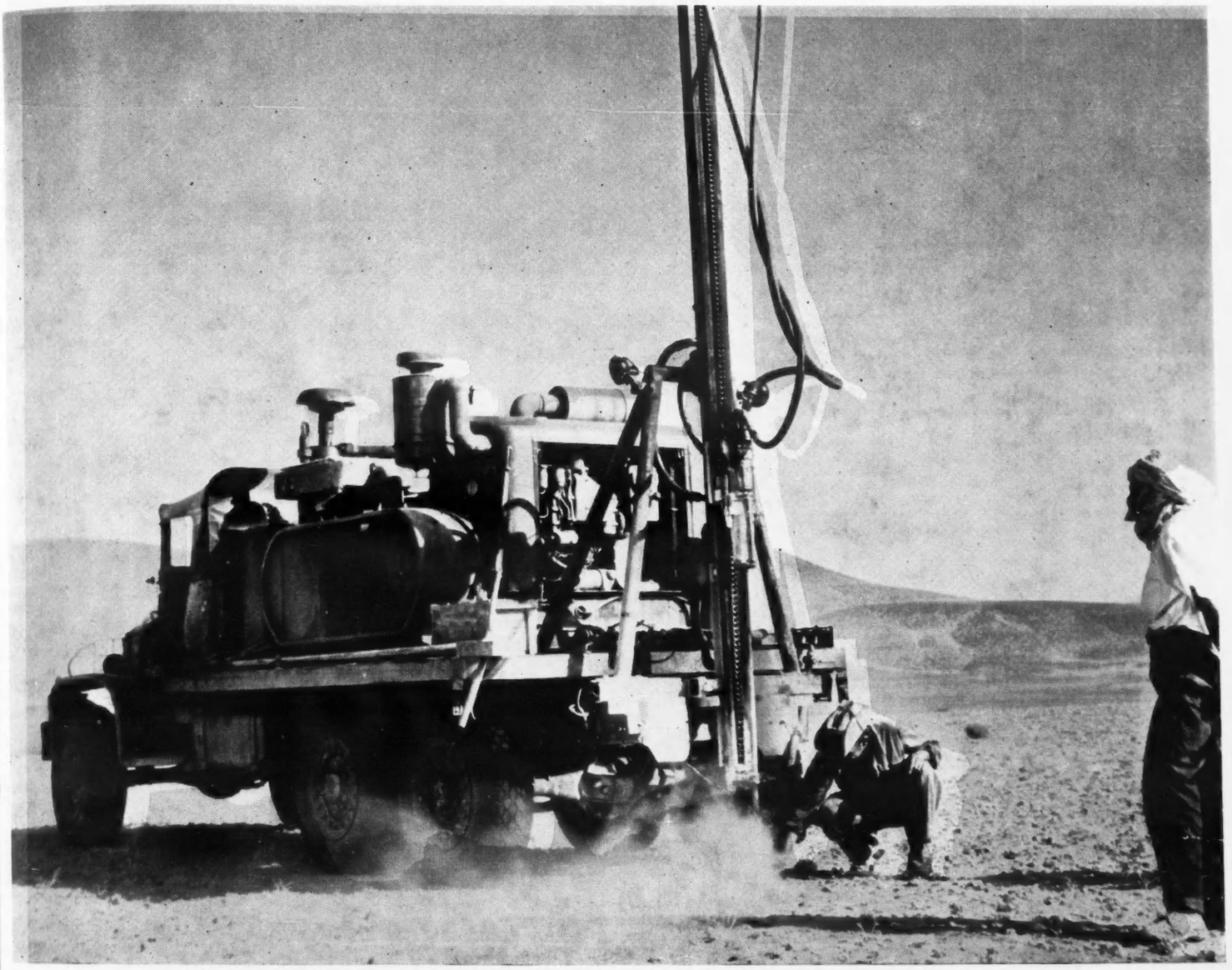

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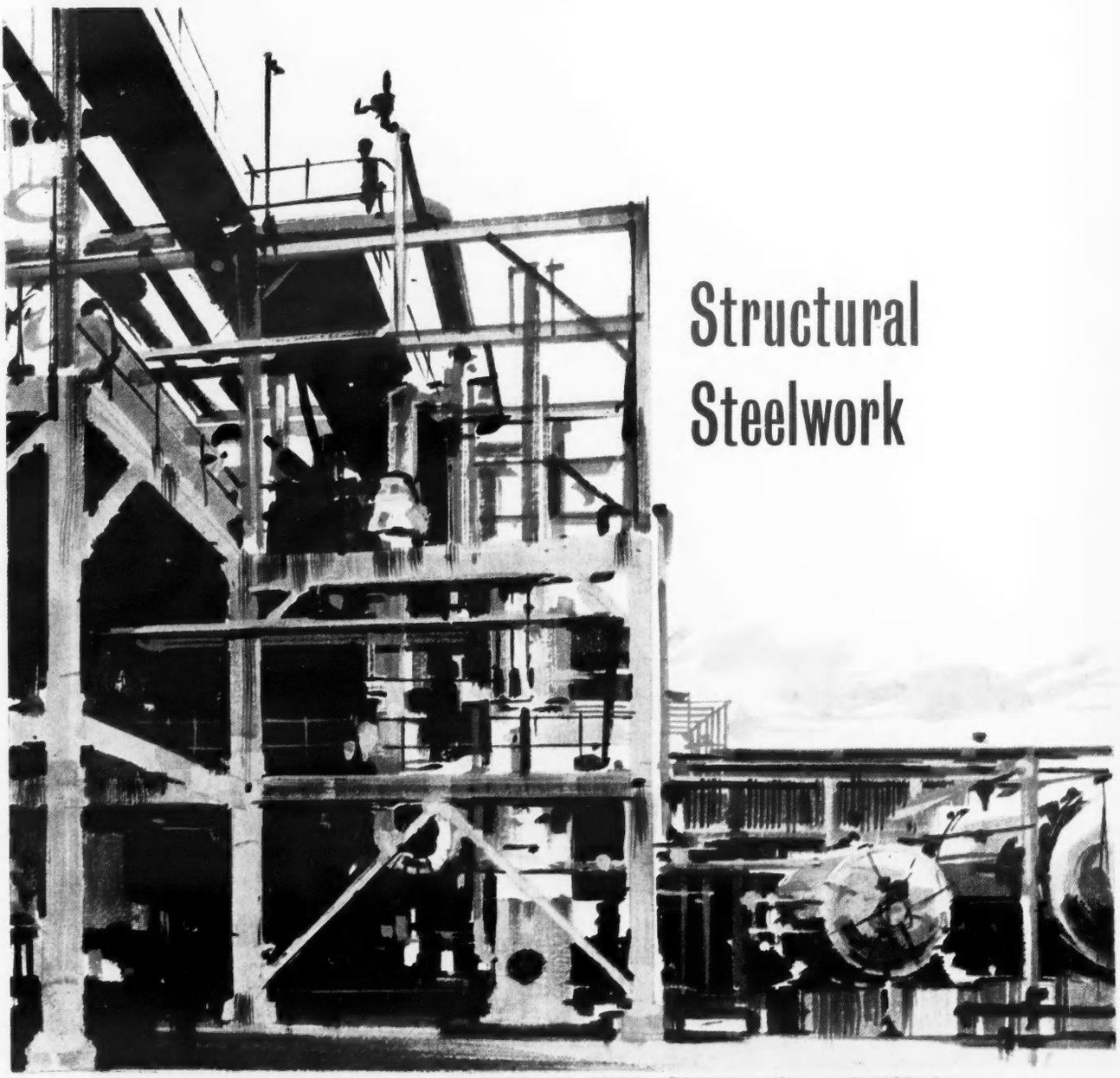

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